SECTION 00 01 01

STATE OF DELAWARE
OFFICE OF MANAGEMENT AND BUDGET
DIVISION OF FACILITIES MANAGEMENT
ARPA CONTRACT #18396C

SPECIFICATIONS
FOR

NEW DELAWARE HOME FOR THE CHRONICALLY ILL

100 SUNNYSIDE ROAD
SMYRNA, DELAWARE 19977

VOLUME III

PREPARED
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BID SET

MARCH 2024

DBF #0586B044.A01

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SECTION 00 01 10

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SECTION 21 00 00

GENERAL REQUIREMENTS FOR FIRE PROTECTION

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PART 1 - GENERAL

1.1 COMMISSIONING

A. Each contractor and vendor shall be part of a total building and system commissioning effort as conducted by the Commissioning Agent. Each contractor shall provide a technician and tools required to assist and facilitate the commissioning agent, as outlined by the commissioning plan. Full scope of work and all related responsibilities will be defined in Commissioning documentation.

1.2 RELATED DOCUMENTS:

A. Division 01 Specifications, General and Supplemental Requirements apply to this section with additions and modifications specified herein.

B. Instructions to Bidders, Bidding Forms, Forms of Agreement between Owner and Contractor, Contract Award Date, Starting and Completion Dates, Conditions of the Contract, Insurance Requirements, and other Owner Requirements will be furnished separately by the Owner. These documents, as well as any addenda issued, shall form a part of these Specifications, and this Contractor shall consult them in detail for instructions pertaining to their work.

C. Each trade contractor shall receive all drawings and specification sections issued as part of the overall bid package. All contractors are to receive, review, and coordinate all of their work as shown or referenced on the other trade documents. All work shown or referenced on the other trade documents shall be included as part of the overall project scope for that particular discipline and trade.

1.3 SCOPE OF WORK:

A. These specifications and accompanying drawings are intended to cover the furnishing of all labor, material, and equipment and superintendence of the Fire Protection System.

B. It is the intent and purpose of these specifications and accompanying drawings to cover and include each item, all materials, machinery, apparatus, and labor necessary to properly install, equip, adjust, and put into perfect operation the respective portions of the installations specified and to so interconnect the various items or sections of the work as to form a complete and properly operating whole.

C. Any equipment, apparatus, machinery, material and small items not mentioned in detail, and labor not hereinafter specifically mentioned, which may be found necessary to complete or perfect any portion of installation in a substantial manner, and in compliance with the requirements stated, implied or intended in these specifications shall be furnished without extra

cost. This shall include all materials, devices or methods peculiar to the machinery, equipment, apparatus, or systems furnished and installed as part of the Fire Protection work.

D. The term "Furnish" shall mean to obtain and supply to the job site. The term "Install" shall generally mean to fix in position and connect for use. Where language indicates that one party or trade is to "install", and another is to "connect", the term "install" shall mean only to fix in position, and "connect" shall mean to make final connections to. The term "Provide" shall mean to furnish and install.

E. Drawings and specifications have been prepared with best knowledge of conditions available at the time of design. If any obscurities or discrepancies exist, they shall be brought to the attention of the Design Professional before bids are submitted. If they are not discovered before bids are submitted, the Design Professional shall be notified and shall render decision. This decision shall be final.

1. Drawings and Specifications are intended to be complementary; items described or shown in one but not both are to be furnished as if fully shown or described in both locations.

1.4 LAWS, REGULATIONS AND CODES:

A. Perform all work in strict compliance with all laws, regulations, and/or codes applying, including all Federal, State and local codes and any other authority having jurisdiction. Wherever drawings or specifications conflict with such regulations they shall be made to conform, and approval of the Design Professional obtained on such damages as may be involved.

B. All Fire Protection work shall comply with the requirements of the National Fire Protection Association (NFPA), International Fire Protection Code (IFC), and local amendments to the code, latest revisions.

1.5 PERMITS, FEES, AND CERTIFICATES OF APPROVAL:

A. Perform all work in strict compliance with all law, regulations, and/or codes applying, including those of the National Fire Protection Association; City of Baltimore; and other local codes and any other authority having jurisdiction. Wherever drawings or specifications conflict with such regulations they shall be made to conform, and approval of the Design Professional obtained on such changes as may be involved.

1. "Fees" shall include connection charges construction costs, and other such charges by utility companies or service providers. Ascertain such charges during bidding period and include bid price.

1.6 REQUESTS FOR INFORMATION (RFI)

A. Contractor is responsible for submitting Requests for Information (RFI)s when discrepancies arise, logical discrepancies are found on the contract documents, or clarification is necessary. All RFIs must be clearly written and submitted with a suggested solution. All RFIs regarding changes to the intent indicated on plans must be accompanied by sketches, explanation, site

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pictures, and all other instruments necessary, to clearly convey the issue at hand and the suggested solution. The RFI process may only be utilized for legitimate purposes. RFIs may not be utilized to submit deviation or substitution requests, nor requesting confirmation of scope for items clearly defined on the contract documents, nor related to clarifications that should be resolved through the Contractor's coordination efforts. RFIs that do not comply will be summarily rejected and any delays caused as a result are the responsibility of the Contractor. In cases where the Contractor does not submit an RFI to clarify an issue and incorrectly proceeds, all work required to resolve such issues to be in compliance with the intent of the contract documents, as determined by the Engineer, shall be the Contractor's responsibility and at no additional cost to the project.

B. The contractors are required to carefully examine all architectural and structural drawings for the building as well as all of the drawings for electrical trades, IT/AV/Security Trades, mechanical trades, plumbing trades and fire protection trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit or equipment. Refer to the coordination drawing requirements. Proper judgment shall be exercised to secure best possible headroom, ceiling heights, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment and conduit, and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.

1.7 RECORD DRAWINGS:

A. During construction keep an accurate record of all deviations of the work as shown on the drawings and that which is actually installed.

B. Secure from the Design Professional, a complete set of prints of the Fire Protection drawings and note changes thereon. Make a complete record in a neat and accurate manner, of all changes and revisions to original design which exist in completed work, in CAD file format.

C. The cost of furnishing above CAD files and preparing these record drawings shall be borne by the Contractor. When all revisions showing the work as finally installed are made, the corrected white prints and CAD files on compact disc shall be submitted for review and approval by the Design Professional.

D. Refer also to Division 01.

E. Electronic CAD files of Fire Protection work will be provided at the conclusion of the project for the purposes of preparing record drawings.

1.8 OPERATING INSTRUCTIONS

A. Provide to the Owner three bound copies of complete written instruction on the operation, care, and maintenance of each piece of equipment and the installation as a whole. Include frequency of inspection, cleaning and adjusting and other attention as may be required in accordance with manufacturer's instructions. Material shall be manufacturer's brochures, catalog cuts, parts lists, wiring diagrams, etc. Also supply Owner with three complete sets of "No Exception Taken" shop drawings.

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B. Furnish qualified personnel to instruct the Owner's personnel in the maintenance and operation of all equipment and systems. Instructing personnel shall remain on the job continuously during working hours until such instruction is complete, but not less than 16 hours.

C. Refer also to Division 01.

1.9 CORRECTION OF WORK AFTER FINAL PAYMENT AND GUARANTEE:

A. This article is supplementary to Guarantee Provisions of Division 01 and General Conditions.

B. Final payment shall not relieve the Contractor of responsibility for faulty equipment, materials and workmanship and unless otherwise specified they shall remedy any defects due thereto and pay for damage to other work resulting therefore, which shall appear within a period of two (2) years from the date of acceptance.

C. Include guarantees by the respective equipment manufacturers which shall be subject to the terms and time limits defined under this Article of Specifications.

D. Guarantees furnished by Sub-Contractor and/or equipment manufacturers shall be counter-signed by the related Prime Contractor for joint and/or individual responsibility for subject item.

E. Manufacturers' equipment guarantees or warranties extending beyond the guarantee period described herein shall be transferred to the Owner along with the Contractor’s guarantees.

1.10 QUALITY ASSURANCE

A. Comply with the requirements of the following codes and/or standards:

1. ANSI
2. ASME
3. ASTM
4. UL
5. NEMA
6. AMCA
7. NFPA
8. Delaware Fire/Sprinkler Code
9. Delaware Life Safety Code
10. ARI
11. NEC
12. IBC

B. All packaged equipment shall be independently Third Party labeled as a system for its intended use by a Nationally Recognized Testing Laboratory (NRTL) in accordance with the OSHA Federal Regulations 29CFR1910.303 and .399, as well as NFPA Pamphlet #70 and National Electric Code (NEC), Article 90-7.

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1.11 WARRANTIES

A. Manufacturer's warranties on equipment provided under this contract shall be included in the operating and maintenance manuals.

B. Warrantee period shall begin when the Owner receives beneficial use of the equipment. The installing contractor shall be responsible for protecting all equipment until the testing and balancing reports are accepted and commissioning reports are submitted.

C. The period of "Owners Beneficial Use" shall begin when:

1. Permanent or temporary certificate of occupancy is granted; or
2. Final Punchlist items are successfully completed; or
3. Owner acknowledges benefits and risks of using the equipment to expedite completion of construction and grants permission for early use of fire protection systems.

D. See specification section regarding restrictions on early use of fire protection equipment.

PART 2 - MATERIALS

2.1 MATERIALS AND EQUIPMENT:

A. All installed materials and equipment shall be new and the best of their kind and shall conform to the grade, quality and standards specified herein.

B. Unless otherwise specifically stated, all materials and equipment offered under these specifications shall be limited to products regularly produced and recommended by the manufacturer for the service intended. This material and equipment shall have capacities and ratings sufficient to amply meet the requirements of the project. The capacities and ratings shall be in accord with engineering data or other comprehensive literature made available to the public by the manufacturer and in effect at the time of opening of bids.

C. Equipment shall be installed in accordance with manufacturer's instructions for type and quality of each piece of equipment used. These instructions shall be obtained from the manufacturer and shall be considered part of these specifications. Type, capacity and application of equipment shall be guaranteed suitable to operate satisfactorily. No experimental material or equipment shall be permitted.

2.2 WORK DESCRIPTION:

A. In general, the work shall consist of but not necessarily be limited to the following:

1. Complete fire protection services terminating 5'-0" outside of building footprint.
2. Complete fire pump booster systems.
3. Wet pipe sprinkler systems and piping.
4. Standpipe Systems.

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5. All miscellaneous pipes, fittings, valves, hangers, anchors, sleeves, plates, flashings, and appurtenances necessary for a complete installation, leaving same ready for service. Unless stated otherwise all control wiring from electrical disconnect to valves, controls, and equipment, requiring same.
6. All excavation and backfilling required.
7. Pipe and valve marking and tags. Painting as noted herein.
8. All testing and adjusting of all systems.
9. Instruction and equipment manuals.
10. Instruction of Owner's representatives.

2.3 WORK INCLUDED:

A. In addition to the work described above under WORK DESCRIPTION. The work shall include but not necessarily be limited to the following:

1. Rigging of equipment and materials related to the Fire Protection Work.

2.4 EXCAVATION AND BACKFILL:

A. Perform all excavating and backfill necessary under this contract. All excavation shall be unclassified, and includes the excavation and removal of all soil, shale, rock boulders, existing foundations, fill and every kind of sub-surface condition encountered in the contract area. No extra or additional compensation for excavation will be paid under this Contract.

B. To protect persons from injury, and to avoid property damage, adequate barricade, construction signs, torches, lanterns, and guards shall be placed and maintained during the progress of the construction work and unit it is safe for traffic use. Rules and regulations of local authorities respecting safety provisions shall be observed.

C. The excavation may be accomplished by machine to within 2 inches of the sub-grade elevation. The excavation shall be completed by hand to neat lines.

D. Trenches shall be instrument graded using batter board and flow line and of sufficient width to provide a free working space of not less than 24 in. width and not greater than 12 in. on each side of the pipe barrel, whichever is greater. Trenches shall also be wide enough to thoroughly ram the backfilling around the pipe and to secure a firm bed.

E. In earth excavation, the trench shall be carried to the invert of the pipe. Where rock excavation is encountered, the trench shall be carried to a point 6 in. below the construction. No construction shall be bedded directly upon rock but shall be cushioned by a 6 in. layer of selected crushed stone or gravel.

F. Where material is removed below the grade of the bottom of a structure it shall be replaced with concrete of the same quality as the concrete in the structure. Where material is removed below the grade of a pipe trench it shall be replaced with a lean concrete mix. Make no excavation to depth below a line of slope one ft. rise on 2 ft. length from such excavation to bottom of footing on other construction.

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G. Any piping that is run in unstable ground shall be supported on 5'-0" centers with concrete or brick piers. These piers shall be not less than 12 inches square and must reset on solid ground. Brick piers shall be laid in cement mortar.

H. Maintain banks at all times by means of shoring and bracing to avoid cave-in and make good any damage done to property or work of others due to failure to properly shore any excavation. Shoring done shall be removed after installation and test of lines have been approved. Material for shoring shall be placed in accordance with the regulations of the Department of Labor and Industry.

I. All excavations shall be left open until inspected and approved by the Design Professional. After the work has been installed, tested, inspected, the excavation shall be backfilled with the best carefully selected materials free from stones, large pebbles, hard lumps on frozen earth. Trenches shall not be backfilled until the work has been inspected and approved by the Design Professional. All backfill shall be made in 8 in. layers. The first 2 layers shall be fine earth, hand tamped. The remainder of the fill over new construction to the surface shall be ordinary approved excavated material placed in 8 in. layers and thoroughly compacted to not less than 90% of maximum Modified Density as determined by ASTM D 1557-70. No water soaking will be permitted. All excess materials shall be disposed of as directed.

J. Where excavation is required under existing walkways and roadways, surface shall be restored with new materials equivalent to the material originally used. Whole cement pavement blocks shall be removed and replaced; removal and repair of partial blocks is not permitted. Seeding shall be by the General Contractor.

2.5 DEWATERING PUMPING:

A. Provide pumping equipment to pump all water to prevent it from collecting in trenches, basement areas, and any other excavations necessary to carry out contract requirements. Prepare run-off trenches as required to pump water into and use surplus earth to form dam at top of excavation to run back surface water.

2.6 CHASES AND OPENINGS:

A. Provide information to the appropriate trades regarding size and location of all openings and chases as required for the installation of this Fire Protection Work.

2.7 CUTTING AND PATCHING:

A. Provide all cutting and patching required for work performed under this Contract. No holes may be cut or drilled in structural members without prior approval of Owner's Representative. Cutting shall be done by mechanics skilled in their respective trades.

B. No cutting that may impair the strength of the building construction shall be done. No holes may be drilled, or attachments welded to the beams or other structural members with prior approval from Owner's Representative. All work shall be done by mechanics skilled in their trade.

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C. All patching shall be done in a manner to match appearance and quality of existing surfaces.

D. Provide sleeves for pipes passing through poured concrete decks, footings, walls, etc. Cut all openings for conduits passing through precast concrete or existing concrete masonry. Such holes shall be cut with core drill or similar equipment. They shall not be cut with hammer and chisel, or with any power tool depending on impact for its cutting power.

E. For holes and openings in pre-cast concrete, 2-1/2" round and above, or 2-1/2" and above on longest side, prepare a drawing for the Design Professional's approval for same to be pre-cast in the factory; for holes and openings smaller than above, prepare a drawing for the Design Professional's approval for same to be cut, cored or drilled in the field by the Fire Protection trade.

2.8 CONCRETE:

A. Provide concrete work required for work performed under this Contract.

B. Concrete shall have a compressive strength of 3,000 psi minimum at twenty-eight days. Placing of reinforcing steel and concrete shall be done according to the recommendations of the American Concrete Institute and Concrete Reinforcing Steel Institute, and all materials shall conform to American Society for Testing Materials Specifications, applicable to this work. Equipment pads shall be properly dwelled in with floor construction and shall have sloped bevels on all horizontal and vertical edges.

C. Form work shall be of sufficient strength to maintain desired shape during pouring of concrete and tight enough to prevent leakage of the grout through joints.

D. Submit shop drawings for approval showing dimensions, reinforcing and dwelling.

E. Concrete pads under equipment shall extend not less than four (4) inches beyond equipment base on all sides and shall be six inches above floor, in all cases not less than is indicated on the Drawings.

F. Provide at the time of pouring concrete, all necessary anchor bolts. Anchor bolts shall be the hook type, of proper size and length to suit the equipment. Anchor bolts shall be set in pipe sleeves of approximately twice the bolt diameter and one half the embedded length of the bolt. Assume full responsibility for proper emplacement of the bolts.

G. Drop-in wedge anchor bolts or self-drilling anchors may be used in place of hook bolts. Minimum embedment in concrete of wedge anchor bolts shall be in accordance with manufacturer's instructions. Wedge anchor bolts shall be manufacturer by Phillips Drill Co. or USM Corp. Self-drilling anchors shall be manufactured by Phillips Drill Co.

H. After equipment is set in place and bolted down, any space between equipment base and floor slab or foundation shall be completely filled with non-shrink grout equal to Master Builders Co., Ltd. Embeco 153 grout.

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2.9 STARTERS AND PILOT DEVICES (OR MOTOR CONTROLS):

A. Combination magnetic motor starters shall be full voltage non-reversing with an adjustable instantaneous-trip circuit breaker & withstand rating 100,000 ampere rms symmetrical with current limiting module or fused or unfused safety switch. Starters and protective devices shall be of sizes recommended by manufacturer for the motor to be controlled, but minimum size shall be NEMA size 1.

B. Combination magnetic motor starters shall be full voltage non-reversing with a fused safety switch. Starters and protective devices shall be of sizes recommended by manufacturer for the motor to be controlled, but minimum size shall be NEMA size 1.

C. Starters, which are not combination shall be similar, but without circuit breaker or switch.

D. Refer to Division 23 and 26 Specifications for description of starter. Unless specified otherwise hereinafter, furnish non-combination starter with "hand-off-auto" selector switch, green "run" pilot light, and two (2) auxiliary contacts.

E. Where starters or other devices are to be mounted outdoors enclosures shall be NEMA Type 4. All other enclosures, unless otherwise noted, shall be NEMA Type 1.

F. All starter control circuits shall be 120V. Voltage shall be derived from starter line voltage via fused control transformer. Control transformers shall have sufficient capacity to properly operate any auxiliary equipment or devices. Provide transformers larger than manufacturer's standard size, as required by these conditions. Provide sufficient auxiliary contacts to properly interface other devices interlocked with the motor in question.

G. Manual starters shall be toggle type, in surface or flush enclosure as required, and with pilot light. Provide overload heaters unless the motor to be controlled is thermally protected.

H. Unless otherwise noted, overload heaters shall be melting-alloy non-automatic-reset type. Overload heaters shall not be selected based on average published motor currents but shall be selected based on the actual nameplate current of motors and service factor as installed.

I. Push buttons, selector switches, pilot lights and similar pilot devices shall be NEMA 1 or NEMA 4, as noted in D, above. Pilot lights shall be neon or transformer type. Provide manufacturer's standard engraved nameplates which display the control function of the device (or for pilot lights, the action indicated).

J. All starters and controls shall be Square D, General Electric, Westinghouse, Allen Bradley, Cutler-Hammer or ITE.

2.10 ELECTRICAL WORK AND MOTORS:

A. All electrical work shall be done in strict accordance with the requirements of the National Electrical Code and the Electrical Specifications. All electrically operated equipment shall bear an Underwriter's Laboratories label where labeling service is available for that type of equipment.

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B. All motor frames shall be grounded. Electric power, control and grounding connections shall be factory wired to an outlet box or terminal strip enclosure on the apparatus for easy connection by the Electrical Contractor.

C. All motors shall be designed and constructed in accordance with the latest standards of the IEEE and NEMA and shall meet UL requirements. Motors shall run quietly under all operating conditions.

D. Single phase motors that are drip-proof or totally enclosed shall have Class A Insulation. Three phase motors 7½ HP and larger shall have Class B Insulation. Three phase motors under 7½ HP that are drip-proof or totally enclosed shall have Class A and Class B Insulation. These requirements are based on an ambient temperature of 40° C and service factor of 1.15 for open drip-proof motors; motors rated for 50°C ambient temperature shall have a factor of 1.0. Totally enclosed motors shall have a service factor of 1.0 in 40°C ambient temperature. Motors shall have the following efficiencies and power factor at full load. Efficiency for 10 to 50 HP shall be 90% and for 60 HP and above shall be 95%. Power factor for 10 HP and above shall be 95%. In lieu of these power factors, provide correction devices at individual motors to correct the above noted power factors. Contractor shall furnish documentation that demonstrates all power factor corrections meet or exceed the requirements noted above.

1. All fractional horsepower single phase motors shall have an integral thermal overload circuit interrupting device with manual reset. If an integral overload is no available, format a motor rated toggle switch with thermal overload to the electrical contractor for installation by electrical contractor.

E. Motors for use on equipment with variable speed drives shall be compatible for drive usage and be constructed per NEMA Standard MG-1 Part 31. Coordinate with variable speed drive manufacturers for motor requirements and drive output characteristics. All such motors shall have their cases bonded to the driven machinery frame with a ground strap. Motors shall be inverter duty and shall be equipped with shaft grounding rings.

F. See Division 23 Specification for additional details.

2.11 WIRING FOR CONTROL SYSTEMS:

A. This Article applies to wiring used for Fire Protection Systems.

B. All wiring for control systems shall comply with Article 725 of the National Electrical Code, (NEC) or with Articles 760, 800, or 820 for control systems integrated into systems covered by those Articles.

1. Particular attention shall be given to the requirements of the NEC for testing and labeling cables for use in plenums, risers, and other air-handling spaces.

C. All wiring for control systems shall be of a type recommended by the system manufacturer and be installed in accordance with systems manufacturer's instructions.

D. Cables must be in raceways when run through inaccessible ceilings, walls, or chases. Comply with Division 26 Specifications, for types of raceways required and their installation

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requirements. Cables run on surfaces within 8' of finished floor must be in raceways where exposed to physical damage.

1. Where cables enter or leave raceways, provide insulated bushing or protective grommet.

E. Cables may be run without raceways above accessible ceilings; in hollow stud partitions; and where properly supported in unfinished spaces without ceilings.

F. Cables run without raceways shall be supported by bridle rings or similar hangers attached to the building structure at maximum 5'-0" centers. Hangers and/or cables shall not be supported from pipes, ducts, or similar equipment. Cables shall not be supported by lying on or across framing members or structural elements.

G. Cables run without raceways shall be run parallel with, or perpendicular to, the lines of the building. Wiring shall be grouped neatly using plastic ties equal to "Ty-raps" at 30" maximum intervals.

H. Wiring with or without raceways shall be run continuously between terminal boxes and outlets. All splices shall be made in NEMA 1 boxes with terminal strips or other acceptable connectors and permanent labels to identify each wire and cable, both entering and leaving the box.

I. A separation of not less than 6" shall be maintained to heated pipelines.

J. Cable run above hung ceilings used for environmental air shall be specifically listed and labeled for the use or shall be installed in a raceway.

K. Wiring run without raceways through rated walls, floors and partitions shall be run in sleeves. All such sleeves shall be packed with fire-rated material.

L. Wiring for different systems shall be grouped and run separately from other systems and shall be identified as to the system it serves.

2.12 SUBSTITUTIONS:

A. Equipment may be shown or specified in several ways:

1. Several manufacturers and model numbers listed; or one manufacturer and model number, followed by "equals by (mfr A), (mfr B), (mfr C)," or words of similar respect.

   a. If one of the manufacturers is listed on the drawings, that manufacturer shall be considered the basis of design. If none is so listed, the first manufacturer named in the Specification shall be considered the basis of design.
   b. Where manufacturer's or supplier's name, style and catalog numbers are mentioned in the description of material and equipment in the specifications or on the drawings, it is to be understood that they are for the purpose of setting a standard.
   c. If Contractor elects to furnish equipment other than the basis of design, they shall verify capacities, physical size, weight, electrical requirements, methods of connection to other parts of the system, and all other relevant data. Contractor

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shall be responsible for informing the Design Professional of all changes required to other equipment, spaces, structure or systems in order to install the substituted equipment. They shall furnish all required shop drawings or sketches required for Design Professional to evaluate the required changes and shall be responsible for all costs associated with such changes, including costs of design or engineering, if such are necessary, and costs of other trades.

2. Where manufacturer's or supplier's names are listed in conjunction with the manufacturer or supplier that is basis of design, they are given to approve the firm name only. Equipment or material submitted by such firms must meet the detailed technical specifications written for the respective item. Contractor shall be responsible for verifying capacities, physical sizes, weights, electrical requirements, methods of connection to other parts of the system, etc. Contractor shall furnish all required shop drawings for equipment, and for its connection and installation.

B. If any substituted items are submitted after contracts have been awarded, and there is any question of equality of such items, samples may be required to be submitted both for the item specified and that to be substituted, or, further proof of equality may be required to the entire satisfaction of the Design Professional. In no case shall additional remuneration be allowed because of the rejection of a substitute.

C. When the equipment is relocated to a place other than that shown on the drawings, or when equipment other than that specified is used, the Contractor shall pay the extra cost of required revisions such as structural steel, concrete, electrical, piping, etc.

D. The Design Professional's costs to evaluate substitutions and to revise Drawings and Specifications because of substitutions will be paid by the Contractor.

2.13 SHOP DRAWINGS:

A. Refer to Division 01.

B. Furnish shop drawings, catalog cuts, performance data and other required data to the Design Professional for approval for all material and equipment specified hereinafter. Sufficient data shall be submitted to show compliance with the requirements of the plans and specifications. All shop drawings submitted shall be first checked and corrected before submitting for approval. Approval for shop drawings by the Design Professional will not relieve the Contractor from responsibility for errors or omissions therein. All such errors or omissions must be made good by the Contractor irrespective of any approval by the Design Professional.

C. The following applies to all materials and equipment being submitted for this project. Refer to the individual specification sections for additional submittal requirements.

D. It is the responsibility of the manufacturer’s representative and the installing contractor to thoroughly review all shop drawing equipment submittals and state in writing that the products meet or exceed the design specifications and design intent as indicated on the contract documents, prior to submitting them for review by the engineer.

E. The General Contractor or Construction Manager shall review and stamp all shop drawings noting their review process has taken place and that the shop drawings are in compliance with

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the design documents, prior to submitting the for review by the engineer. Any shop drawings found to not be in compliance shall be returned to the contractor stating such, with a copy of the statement (only) forwarded to the engineer.

F. On submissions beyond the initial one, clearly identify all of the changes made from the initial submittal those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.

G. The Engineer will review three submissions (one original submission and up to two revised submissions) on any single component requested for review. If the contractor and/or vendor fail to comply with the drawings, specifications, and/or review comments and additional submissions are required, the cost for review and processing of those submissions will be borne by the contractor.

H. The design documents are based and coordinated on the scheduled manufacturers. Any substitutions of products or materials (from those approved and listed in the specifications) must be thoroughly coordinated by the submitting contractor. This includes but is not limited to power, space, structural, control and performance requirements.

I. Shop drawings required shall include, but not necessarily be limited to, the following:

1. Shop drawings, cuts and catalog information showing appearance, dimensions, performance, weight, etc., of all equipment, appurtenances, etc.
2. Schedules of all materials showing type and manufacturer.
3. Wiring diagrams and schematics for equipment.
4. All special equipment and systems.
5. Any special constructions.
6. Other shop drawings as may be requested.

J. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristic, finishes for materials, and installation and startup instructions for each type of product indicated.

1. Each control device labeled with setting or adjustable range of control.

K. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Schematic flow diagrams showing all controlled equipment and control devices.
2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
3. Details of control panel faces, including controls, instruments, and labeling.
4. Written description of sequence of operation.
5. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
6. Listing of connected data points, including connected control unit and input device.
7. System graphics indicating monitored systems, data (connected and cSMSulated) point addresses, and operator notations.
8. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.

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L. Shop Drawings shall be submitted and shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Shop drawings shall also contain complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, calculations, and any other details required to demonstrate that the system will function properly. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work.

M. Shop Drawings shall be approved before any equipment is installed. Therefore, shop drawings must be submitted in time for review so that all installations can be completed per the project completion schedule. Ten working days shall be allowed for submittals to be reviewed.

N. All drawings shall be reviewed after the final system checkout and updated or corrected to provide "as-built" drawings to show exact installation. All shop drawings will be acknowledged in writing before installation is started and again after the final checkout of the system. The system will not be considered complete until the "as-built" drawings have received their final approval. The Contractor shall deliver a complete set of "as-built" drawings.

O. On submissions beyond the initial one, clearly identify changes made from the initial submittal other than those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.

P. If the Contractor elects to proceed to install equipment for which approved Shop Drawings have not been received, they do so at their own risk; Design Professional is not obligated to accept such equipment or work, nor will Design Professional be liable for claimed costs or delays required by correction of such work.

Shop Drawing Review Comment Definitions

A> No Exception Taken:

The shop drawing or equipment submittal as submitted is approved without exception. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

B> Make Corrections Noted:

The shop drawing or equipment submittal as submitted is not completely correct but is approved as noted. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted can be released for fabrication and construction once the corrections have been made. The submittal must be corrected and resubmitted for record unless noted by "E: Resubmit". See "E: Resubmit definition below.

C> Submit Specified Item:

The shop drawing or equipment submittal as submitted is missing a component of the system that it represents or is not of the approved and specified manufacturers. Submit the missing or incorrect item. The materials, equipment or system submitted cannot be released for fabrication and construction.

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D> No Further Submission Required:

The shop drawing or equipment submittal as submitted is approved as noted. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

E> Resubmit:

The shop drawing or equipment submittal as submitted is not approved. The shop drawing or equipment submittal needs significant corrections and does require another submission to verify that the comments and changes have been incorporated. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted cannot be released for fabrication and construction.

F> Rejected:

The shop drawing or equipment submitted is not as specified or a non-approved manufacturer or product and rejected.

G> Resubmit for Record Only:

Make the corrections noted on the shop drawing or submittal. The shop drawing or equipment submittal as submitted is approved with minor exception. Changes or corrections are required. The materials, equipment or system submitted can be released for fabrication and construction.

2.14 FIRE STOPPING- GENERAL:

A. All penetrations through fire-resistance-rated floor, fire resistance rated, floor/ceiling assemblies and roof construction and through fire-resistance-rated walls and partitions shall be fire stopped.

B. Penetrations to be fire stopped include both empty openings and those containing cables, pipes, ducts, conduits and any other items.

C. Fire rating of sealed penetrations shall meet or exceed the rating of the assembly being penetrated.

D. Materials shall be installed in accordance with manufacturer's recommendations and their UL listing.

E. Penetrations in Fire Resistance Rated Walls: Provide firestopping with ratings determined in accordance with UL 1479 or ASTM E 814.

1. F-Rating: Not less than the fire-resistance rating of the wall construction being penetrated.

F. Penetrations in Horizontal Assemblies: Provide firestopping with ratings determined in accordance with UL 1479 or ASTM E 814.

1. F-Rating: Minimum of 1-hour rating, but not less than the fire-resistance rating of the floor construction being penetrated.

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2. T-Rating: when penetrant is located outside of a wall cavity, minimum of 1-hour rating, but not less than the fire-resistance rating of the floor construction being penetrated.
3. W-Rating: Class 1 rating in accordance with water leakage test per UL 1479.

G. Penetrations in Smoke Barriers: Provide firestopping with ratings determined in accordance with UL 1479 or ASTM E 814.

1. L-Rating: Not exceeding 5.0 cfm/sq. ft. of penetration opening at both ambient and elevated temperatures.

H. Mold Resistance: Provide penetration firestopping with mold and mildew resistance rating of as determined by ASTM G21.

I. Refer to Division 07. Subject to compliance with through penetration firestop systems (XHEZ), joint systems
(XHBN), and perimeter firestop systems (XHDG) listed in Volume 2 of the UL Fire Resistance Directory: provide products of the following manufacturers as identified below:

1. Hilti, Inc.
2. Approved Equal.

J. Use only firestop products that have been UL 1479 or ASTM E 814 tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire-rating involved for each separate instance.

K. Pre-installed firestop devices for use with noncombustible and combustible pipes (closed and open systems) penetrating concrete floors and/or gypsum walls, the following products are acceptable:

1. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic or polypropylene sleeve lined with an intumescent strip, an extended rectangular flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket. Cast-in place devices for use with only noncombustible penetrants shall be black in color. Cast-in devices for use with combustible or noncombustible penetrants shall be red in color.
2. Hilti Cast-In Place Firestop Device (CP 680-P) for use with combustible penetrants.
3. Hilti Cast-In Place Firestop Device (CP 680-M) for use with noncombustible penetrants**.**
4. Drop-In Firestop Devices: Factory-assembled devices for use with combustible or noncombustible penetrants in cored holes within concrete floors. Device shall consist of galvanized steel sleeve lined with an intumescent strip, an extended rectangular flange attached to one end of the sleeve for fastening to concrete floor, and neoprene gasket.
5. Hilti Firestop Drop-In Device (CFS-DID) for use with noncombustible and combustible penetrants.

a. Blocks/Plugs: Intumescent flexible block/plug suitable for reuse in re-penetration of openings. Blocks shall allow up to 12” of unreinforced annular space.

1) Hilti Firestop Block (CFS-BL)
2) Approved Equal.

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PART 3 – EXECUTION

3.1 WORKMANSHIP:

A. All work shall be installed in a first class, neat and workmanlike manner by mechanics skilled in the trade involved. All details of the installation shall be mechanically correct. Should the Design Professional direct removal, change, or installation of any equipment's or systems not installed in a neat and workmanlike manner, such changes shall be made by the Fire Protection Contractor at no expense to the Owner.

B. Equipment shall be installed in strict accordance with manufacturer's instructions for type and capacity of each piece of equipment used. The Contractor shall obtain these instructions from the manufacturer and these instructions shall be considered part of these Specifications.

C. Drawings and specifications have been prepared with best knowledge of conditions available at the time of design. If any obscurities or discrepancies exist, they shall be brought to the attention of the Design Professional before bids are submitted. If they are not discovered before bids are submitted, the Design Professional shall be notified and shall render decision. This decision shall be final.

1. Drawings and Specifications are intended to be complementary; items described or shown in one but not the other are to be furnished as if fully shown on described in both locations.

D. Drawings are generally indicative of the work to be installed, but do not indicate all bends, fittings, and specialties which may be required, or the exact locations of all piping and ductwork. Contractor shall investigate structure and finish conditions affecting their work and arrange their work accordingly; furnishing such fittings as may be required to meet such conditions. Contractor is responsible for exercising proper judgment to arrange their work and materials so as to avoid interference with other trades.

1. Riser diagrams and schematics generally indicate equipment to be used in various systems involved. This information may or may not be duplicated on the plans, but equipment shown on either plans or riser diagrams and schematics shall be provided as if shown on both.
2. All grades, elevations, dimensions and clearances of equipment shown on drawings are approximate and shall be verified at site.
3. Where work or equipment is referred to in singular terms, such reference shall be deemed to apply to as many items of work or equipment as required to complete entire installation.

3.2 LINES AND GRADES:

A. Lay out work and establish heights and grades for work in strict accordance with the intent expressed by the drawings and all the physical conditions at the building and be responsible for the accuracy of same.

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3.3 FIELD MEASUREMENTS:

A. Before ordering any material or doing any work, verify all measurements at the building and site and be responsible for the correctness of same. No extra compensation will be allowed on account of differences between actual dimensions and measurements and those indicated on the drawings. Any difference which may be found shall be submitted to the Design Professional for consideration before proceeding any further with the work.

3.4 DELIVERY OF EQUIPMENT:

A. Be responsible for delivery of equipment, unload and store in a manner not to interfere with the operation of other trades. Additional expense incurred because of equipment or material delivery delays shall be assumed by the responsible Contractor.

3.5 PROTECTION OF WORK:

A. All work, equipment and materials shall be protected at all times.

B. All piping openings shall be closed with caps or plugs during installation. All equipment shall be tightly covered and protected against dirt, water, plaster, paint and other foreign material or mechanical injury during entire progress of installation. Make good all damage caused either directly or indirectly by workmen employed to fulfill requirements of the Fire Protection Work.

3.6 REMOVAL OF RUBBISH:

A. During the course of construction, periodically remove from the premises all rubbish resulting from work of this trade so as to prevent its accumulation. At the completion of the work contemplated under these Specifications remove from the building and site all rubbish and accumulated materials of whatever nature not caused by the other trades and leave work, and equipment free of all foreign matter including plaster, cement, and paint and leave in a clean, orderly, acceptable and usable condition.

3.7 COORDINATION:

A. Work in conjunction with each of the other trades to facilitate proper and intelligent execution of work with minimum interference.

B. Carefully examine all architectural and structural drawings for the building and drawings for electrical trade and other mechanical trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit or equipment. Proper judgment shall be exercised to secure best possible headroom, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment and conduit: and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.

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C. Contractor shall prepare preliminary shop drawings suitable for use in coordinating their work with the work of other trades. The HVAC section will prepare and furnish CAD files of drawings prepared at 3/8" = 1'-0" scale with all trades indicating piping, ductwork and conduit in relation to all structural elements of the construction, including floor elevations; steel locations, size, and elevations; partitions locations; door locations and direction of swing; and all other information required to assure coordination of the electrical, sheet-metal and piping trades and fire protection in relation to the Architectural function of the project. Coordination meetings will be held under the supervision of the Owner's Construction Manager and General Contractor. Each trade shall have proper representation at all coordination meetings for the purpose of detailing, on a print of the CAD drawing mentioned above, the exact location and routing of their work. After the conclusion of the coordination at the working meetings, each trade shall sign the coordinated print, copies of which shall be distributed by the GC to all contractors and parties concerned including the Owner. The final shop drawings of all trades shall be revised to be in accordance with the coordinated drawing. A print of each final coordinated CAD shop drawings with the participating contractors "sign off" signatures appended shall be submitted to the Design Professional for final record.

D. If contractor installs work so as to cause interference with work of other trades, they shall make necessary changes in work to correct the condition without extra charge.

E. Dimensional layout plans of equipment rooms shall be made showing all bases, pads and inertia blocks required for mechanical equipment. Include dimensions of bases, bolt layouts, details, etc.

F. Contractor shall furnish all necessary templates, patterns, etc. for installing work and for purpose of making adjoining work conform, furnish setting plans and shop details to other trades as required.

3.8 COORDINATION OF CONTROL EQUIPMENT:

A. The Fire Protection Contractor shall furnish all starters, push buttons for local or remote control, controllers, pressure switches, or similar items together with all appurtenances and accessories required to operate the equipment furnished under these specifications and necessary to perform the operating functions as specified shown on the drawings, or otherwise required.

B. Refer to equipment specification for type of controls required. The Electrical Contractor will mount and provide power-wiring for all starters and will furnish and install all other safety switches or other line-disconnecting or protective devices. Where the starter and/or safety switch is an integral part of the equipment assembly, the assembly shall be furnished with the wiring complete between starter, controller and motor and the Electrical Contractor will make power connections only.

C. All control wiring to automatic-operated switches, pressure switches, aquastats or other devices which actuate the starter or other items associated with the systems shall be furnished, installed and wired by the Fire Protection Contractor.

D. The Electrical Contractor will supply 120V electric power to the control panels for these special systems to the extent shown on Electrical Drawings. All other wiring (including additional power circuit if required) shall be the responsibility of the Fire Protection Contractor.

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E. The Fire Protection Contractor shall carefully check the current characteristics available to each location before ordering motors.

F. If procurement requirements necessitate a change in voltage, phase, size or other characteristics of any motor, the Fire Protection Contractor shall obtain approval of such change from the Design Professional and shall be responsible for necessary arrangements for notifying the Electrical Contractor, and shall pay the costs, if any, required by the change, including Engineering costs.

G. All electrical equipment furnished and installed under this contract shall be furnished with full complement of control equipment, control wiring, conduit, and all other items necessary for satisfactory operation.

H. The Electrical Contractor will complete all electrical power connections, through the disconnect and/or thermal cutouts, starter and motor terminals. They will be responsible for final power connections.

I. The Electrical Contractor will be responsible for proper rotation of three phase equipment.

J. All electrical work, equipment and material furnished under this Section shall be furnished and installed in accordance with Sections 260000 and 260100 of the Electrical Specifications.

K. All panels, relays, terminal boxes, contactors, circuit breakers, safety switches, motor starters and similar items shall be identified by Name, Function and/or Control. Nameplates shall be at least 1" x 3" with characters not less than ¼". They shall be made of two laminated black plastic sheets bonded with a middle sheet of white plastic and characters engraved in one black sheet to the depth of the white plastic. A typewritten list of Nameplates shall be submitted to the Design Professional for approval before ordering same.

3.9 ANCHORS AND GUIDES:

A. Anchors shall be provided where shown and/or required for the proper control of stress in piping due to expansion. Anchors shall be made of heavy cross section and securely fastened to concrete construction by anchor bolts set in concrete before pouring or bolted or welded to building structural steel. Submit shop drawings of anchor details for approval. Provide guides, Metraflex Style I, II, and III, Adsco or approved equal; wrap duct tape between copper tubing and guide clamp.

3.10 FIRE STOPPING:

A. All penetrations through fire-resistance-rated floor, fire resistance rated, floor/ceiling assemblies and roof construction and through fire-resistance-rated walls and partitions shall be fire stopped.

B. Penetrations to be fire stopped include both empty openings and those containing cables, pipes, ducts, conduits, and any other items.

C. Fire rating of sealed penetrations shall meet or exceed the rating of the assembly being penetrated.

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D. Materials shall be installed in accordance with manufacturer's recommendations and their UL listing.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain equipment.

B. Provide 16 hours of training will be required by the Owner for the various systems (Fire Alarm, Security, Generator, Boilers, HVAC Equipment, Building Management, Lighting Control, etc...). This will be done in (4) four, (4) four-hour sessions as scheduled with the Owner on different days. Training should be videotaped for future use/reference.

3.12 COMMISSIONING

A. The installing contractor shall provide a field technician and specialized tools to facilitate a successful site system commissioning and testing for all equipment and systems. This contractor and technician shall be part of the overall commissioning team. Where applicable and required, the contractor shall secure and pay for a factory technician to be part of the startup, testing and commissioning team and efforts.

1. All equipment shall be commissioned, and the operation of that equipment shall be checked by the installing contractor. Specific systems shall be commissioned when more than one contractor is involved in the installation or there is multiple system interface and control involved with that piece of equipment.
2. The contractors shall check and verify all equipment nameplate data against the design parameters, prior to installation.
3. The contractors shall submit a Spare Parts List for all equipment in the Maintenance and Operations Manuals to include, but not limited to the following:

    a. Part Numbers
    b. Part and Equipment Description
    c. Quantity of Parts Required
    d. Lubrication Requirements
    e. Full Warranty Information
    f. Complete Operation and Maintenance Manuals

END OF SECTION 210000

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SECTION 21 00 05

COORDINATION DRAWING REQUIREMENTS FOR FIRE PROTECTION

PART 1 – GENERAL

1.1 COORDINATION DRAWINGS

A. All mechanical, electrical, plumbing, fire protection, telecommunications, and ATC subcontractors will be required to use AutoCad (CAD) format. Coordination drawings will be distributed via email and/or disk.

1.2 ABOVE CEILING AND NO CEILING OVERHEAD INSTALLATION

A. The Mechanical Contractor shall furnish minimum 1/4" scale CAD electronic background drawings of the sheet-metal shop drawings, for incorporation of plumbing and mechanical piping services. All ductwork and piping systems shall be thoroughly dimensioned as to location and height above finished floor. Each different system will be drawn in a different color. Upon conclusion of the various systems coordination with the Sheet-Metal Contractor, the composite drawing shall be distributed by the Construction Manager for contractor coordination. All lighting fixture locations will be "ghosted in" by the Sheet-Metal Contractor for coordination of the same. The Sheet-Metal Contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the Sheet-Metal, HVAC Piping, Plumbing, Fire Protection, Electrical, Telecommunications and ATC firms, with the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."
>
> NOTE: The composite drawing is in addition to separate shop drawings to be submitted at the conclusion of the coordination process.

B. At the conclusion of each composite drawing coordination process, the Construction Manager shall be notified by the Mechanical Contractor Project Manager. The Mechanical Contractor Project Manager shall then schedule an on-site coordination meeting for the purpose of signing off on the respective drawing. The Mechanical Contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.

C. The Mechanical Contractor shall print a weekly status log and maintain a file for the project on this process. Each subcontractor is responsible to submit and coordinate their work with the Construction Manager and Mechanical Contractor.

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D. The Fire Protection Contractor shall overlay their complete piping system on a composite background drawing furnished by the Mechanical Contractor. The Fire Protection Contractor shall utilize a different color from that previously used by the HVAC and Plumbing draftsmen. The Fire Protection Contractor shall cooperate in the coordination process by the relocation of their piping as required to facilitate coordination. When completed, Sprinkler Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the entire coordination process, the Fire Protection Contractor shall be responsible for attending a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signatures to the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."
>
> NOTE: The composite drawing is in addition to a separate sprinkler piping shop drawing to be submitted at the conclusion of the coordination process.

E. The Electrical Contractor shall be responsible to overlay their major conduit racks and equipment, as well as verifying all lighting fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. All conduits larger than 2" shall be documented. When completed, Electrical Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Electrical Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

F. The Plumbing Contractor will be responsible to overlay their major piping racks and equipment, as well as verifying all plumbing fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Plumbing Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Plumbing Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

G. The Telecommunication Contractor will be responsible to overlay their major communication racks and cable tray, as well as verifying locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Telecommunication Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Telecommunication Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

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"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

H. Provide survey and coordination of underground plumbing for verification of location.

I. Drawings, if available, may be obtained electronically from the Architect through the Construction Manager.

J. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall receive hard copies of all drawings.

K. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall review all drawings and advise if any additional drawings are needed.

L. The Mechanical Trade Contractor shall take the lead and develop a drawing list for submissions and a submission schedule coordinated with the construction activities. The drawings shall be developed in a sequential fashion so as to no delay installation of the work or the overall project schedule. The lead Mechanical trade contractor shall include a master key plan so that the area of each drawing can be readily identified as to the location within each building. The Plumbing trade contractor shall lead the underground coordination and the HVAC trade contractor shall lead the balance of the coordination work. The drawing list and schedule shall be forwarded to the Construction Manager for review.

M. Pursuant to Construction Manager approval of the list and schedule, the Mechanical trade contractor shall provide to all participants the latest plans in a timely fashion in accordance with their schedule.

N. Prior to the start of the work, each subcontractor shall forward an insulation schedule to the Construction Manager M.E.P. Coordinator. The schedule shall show the size and thickness of each type of insulation and its intended use.

1.3 ACCESS FLOOR INSTALLATION

A. Coordination drawings for systems to be installed in the access floor shall be prepared in the same manner as described for the overhead installation.

1.4 SHEET-METAL / PIPING / ATC / ELECTRICAL ACCESS / MAINTENANCE CLEARANCES

A. As soon as practical, the Mechanical trade contractor shall prepare layout drawings (not less than 3/8" scale) of all ductwork and piping. These drawings shall show all WALL FIRE RATINGS, registers, grilles, diffusers and similar features, as well as locations of all valves, dampers, damper operators and other items requiring access for maintenance. It shall also be the responsibility of the Mechanical trade contractor to show on these drawings; beams with bottom elevations, ceiling heights, wall-to-wall dimensions, partitions, columns, windows, doors, electric lighting layouts as shown on the reflected ceiling plans, acoustical ceiling grid, and other major architectural and structural features as shown on the General Construction Drawings. All dimensions should be

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from centerlines of columns. All required access to equipment for service and/or required for NEC code required clearances shall be shown in a dotted zone.

B. The Mechanical trade contactor, upon completion of their work, shall email their data back to the Plumbing trade contractor and copy all participants. The Plumbing trade contractor shall download the mechanical data and incorporate, by separate layer, their own routing, as well as other areas requiring access for service and maintenance to determine their relationship and possible interferences with the mechanical, architectural or structural features to be performed as part of the work.

C. The Plumbing trade contractor shall then email their data to the Electrical trade contractor and copy all participants. The Electrical trade contractor shall download the drawing and incorporate, by separate layer, their own routings, as well as the depth of all light fixtures, access panels, etc., as required to determine the relationship and possible interferences with plumbing, mechanical, architectural or structural items to be installed as part of the overall work. The Electrical trade contractor shall be responsible to verify that the electrical lighting layout shown on these drawings is correct and to make corrections and additions of all other light fixtures as required. In areas where no mechanical work occurs, but where other crowded electrical installations are evident, the Electrical trade contractor shall prepare similar drawings.

D. The Electrical trade contractor shall then email the Fire Protection trade contractor and copy all participants. The Fire Protection trade contractor shall download the drawing and incorporate, by separate layer, their own routings, as well as other areas requiring access for service and maintenance, to determine their relationship and possible interferences with the mechanical, electrical, plumbing and architectural or structural items to be installed as part of the overall work.

E. The Mechanical trade contractor shall provide one composite set of reproducible drawings and forward them to the Construction Manager. This composite shall then be reviewed during meetings determined by the Construction Manager, at which all subcontractors including their subcontractors, as required by the Construction Manager, shall be represented to review and resolve any real or apparent interference or conflicts.

F. In the preparation of all the final composite drawings, large scale details, as well as cross and longitudinal sections shall be made as required to fully delineate all conditions. Particular attention shall be given to the locations, size and clearance dimensions of equipment items, shafts and similar features. The final composite drawings shall include the locations of all controls, tie-ins, connections for other subcontractor's work, and pipe and duct insulation as required.

G. Final composite drawings shall then be signed off by each trade subcontractor indicating their acceptance and approval of the indicated routings and layouts and their relationship with the adjoining or contiguous work of all subcontracts. Thereafter, no unauthorized deviations shall be permitted. If deviations are made without the knowledge and agreement of Construction Manager and other affected trade contractors, the work in question shall be subject to removal and correction at no additional cost.

H. In preparing the composite drawings, minor changes in duct, pipe or conduit routings that do not affect the intended function may be made as required to avoid space conflicts, when mutually agreed. Items may not be resized, exposed items relocated, or items run exposed when not intended, without approval. No changes shall be made in any structural members or architectural

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features which affect the function or aesthetics of the buildings. If conflicts or interferences cannot be satisfactorily resolved, the Engineer shall be notified, and their decision obtained.

I. After final composite drawings have been accepted and approved, and signed by ALL subcontractors, the Mechanical trade contractor shall provide and distribute one sepia and two prints to each of the subcontractors, and one sepia and four prints each to Construction Manager. Subcontractors requiring further prints for their own distribution will possess sepias to accomplish same. The original signed-off mylars shall be sent to Construction Manager for permanent possession.

J. The record copies of final composite drawings shall be retained by each subcontractor as a working reference. All shop drawings, prior to their submittal to Construction Manager, shall be compared with the composite drawings and developed accordingly by the subcontractor responsible. Any revisions to the composite drawings, which may become necessary during the process of the work, shall be noted by all subcontractors and shall be neatly and accurately recorded on the record copies. Each trade contractor shall be responsible for the up-to-date maintenance of their own record copies of the composite drawings and to keep one copy available at the site. The composite drawings and any subsequent changes thereto, shall be utilized by each subcontractor in the development of their as-built drawings. NOTE: The coordination drawings may be used with appropriate changes as as-builts and changes to title block.

K. Preparation of coordination drawings shall commence as soon as possible after award of the subcontract. The coordination drawings may lack complete data in certain instances pending receipt of equipment drawings, but sufficient space shall be allotted for the items affected. When final information is received, such data shall be promptly inserted on the composite by that trade contractor.

L. Coordination is the responsibility of all trade contractors. Construction Manager will call meetings, weekly, or as required, which subcontractors must attend to avoid delay. Failure to attend shall require the trade contractor to field run the work not coordinated. No extra compensation will be paid to any trade contractor for relocating any duct, pipe, conduit or other material that has been installed without proper coordination. If the installation of any uncoordinated work or improper installation or coordinated work necessitates additional work by other subcontractors, at the cost of such additional work shall be assigned to the trade contractor responsible as determined by Construction Manager.

M. All changes in the work of any subcontract shall be shown on the composite drawings.

N. All work on the coordination composite drawings shall be performed by competent CAD operators, in a clear legible manner. Each trade contractor shall execute a typical drawing activity in no more than three working days. It shall be the responsibility of each subcontractor to supply a sufficient number of CAD operators so as not to delay the coordination process. Construction Manager and Engineer shall be the judge of the acceptability of the drawings.

O. The composite drawings shall not be used for as-built drawings. (See Paragraph above)

P. It shall be further understood that each trade contractor's specified submittals shall be transmitted for approval during the coordination period in order that the project encounter no delays.

Q. The Mechanical trade subcontractor shall pre-coordinate all control equipment locations with the designated ATC trade subcontractor and indicate it on the composite document.

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1.5 REQUIREMENTS

A. All Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC trade contractors shall be required to use AutoCad (CAD) format. Coordination drawings shall be distributed via email or diskettes. ALL EMAILS SHALL BE COPIED TO CONSTRUCTION MANAGER, ENGINEER, AND PROJECT MANAGER.

B. The Sheet-Metal trade contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the sheet-metal, HVAC, piping, plumbing, sprinkler, electrical and ATC firms with the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

C. The Mechanical trade contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.

D. The Mechanical Contractor shall print a weekly status of all emails sent and received and maintain a hard copy file for use at the coordination "sign-off" meetings. Each subcontractor is required to check emails daily.

E. Submittals: Once the coordination process has been completed, the coordination drawings shall be submitted to the Engineer for review. A single-color plot, as well as three blue print copies of the drawings shall be submitted for review. The color plot shall delineate between the various disciplines by utilizing different color pens for each system.

PART 2 – PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION (NOT APPLICABLE)

END OF SECTION 21 00 05

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SECTION 21 05 17

SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Grout.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

C. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Jay R. Smith Mfg. Co.
2. Zurn Industries, LLC.

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3. Approved equal.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT Industries.
4. Metraflex Company.
5. Proco Products, Inc.
6. Approved Equal.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.4 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

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1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

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3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves.
b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves.

2. Exterior Concrete Walls below Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.

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5. Interior Partitions:

   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 21 05 17

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SECTION 21 08 00

FIRE PROTECTION COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including General and Supplementary Conditions and other Division 1 specification sections apply to this section.

B. ASHRAE Standard 202

C. NFPA 3

D. Commissioning Plan

E. Related Sections

1. 01 33 00 Submittals
2. 01 36 00 Construction Operations Building Information Exchange (COBie)
3. 01 74 10 Construction Indoor Air Quality Management
4. 01 78 10 Project Record Documents
5. 01 78 22 Operations and Maintenance Data
6. 01 79 00 Demonstration and Training
7. 01 91 13 Commissioning Requirements
8. 01 91 20 COBie Information Delivery Plan
9. Division 21 requirements for work in those Sections
10. Division 22 requirements for work in those Sections
11. Division 23 sections that are covered by the systems to be commissioned.
12. Division 26 sections that are covered by the systems to be commissioned.

1.2 SUMMARY

A. Section includes commissioning process requirements for Fire Protection systems, assemblies, and equipment.

B. The commissioning process does not remove or reduce the responsibility of the contractor to provide a finished and fully functioning product. Commissioning should not add to the overall work effort. Commissioning puts a focus on following standard installation and startup procedures, documenting them, resolving issues in a timely manner, verifying the Owner's Project Requirements through equipment, system and integrated system testing, to permit a smooth turnover and acceptance at the end of the project.

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1.3 DESCRIPTION

A. Commissioning: Commissioning is a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meet defined objectives and criteria. The Commissioning process begins at project inception (during the pre-design phase) and continues through the life of the facility. The commissioning process includes specific tasks to be conducted during each phase in order to verify that design, construction, and training meets the owner's project requirements.

B. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:

1. Verify that applicable equipment and systems are installed according to the contract documents, manufacturer's recommendations, and industry accepted minimum standards and those they receive adequate operational checkout by installing contractors.
2. Verify and document proper performance of equipment and systems.
3. Verify that O&M documentation left on site is complete.
4. Verify that the owner's operating personnel are adequately trained.

1.4 COORDINATION

A. Coordinate all sub-trades, other divisions, manufacturers, suppliers and other specialists as required to ensure all phases of work shall be properly organized prior to commencement of each particular startup, testing and commissioning procedure.

B. Coordinate the activities of this Section with the Commissioning requirements of:

1. Division 1
2. Division 21
3. Division 22
4. Division 23
5. Division 25
6. Division 26
7. Other equipment and systems testing specified in this and other Divisions.

C. Where any equipment or systems require testing prior to starting, ensure that such work has been completed and approved prior to starting of the equipment and or systems.

1.5 RESPONSIBILITIES

A. The Fire Protection Commissioning process for the vendors/subcontractors consists of:

1. Facilitate the coordination of commissioning and provide to the General Contractor (GC) commissioning activities for incorporation into the Overall Project Schedule (OPS).
2. Provide detailed startup procedures.
3. Include the cost of commissioning in the total contract price.
4. Ensure that all subcontractors and vendors execute their commissioning responsibilities according to the contract documents and the OPS.

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5. Provide copies of all submittals as required in Section 01 33 00 including all changes thereto.
6. Attend and participate in commissioning team meetings held as necessary throughout the construction and acceptance phases.
7. Provide the training of owner personnel.
8. Review and perform Pre-Functional Checklists (PFC) provided by the CxP.
9. Provide test reports as required by Division 21, 22, 23, and 26 to the CxP for review.
10. Cooperate with the CxP for resolution of issues recorded in the Issues Log.
11. Perform work associated with deficiencies identified on the Issues Log and during Functional Performance Testing.
12. Prepare O&M manuals, according to the contract documents, including clarifying and updating the original sequences of operation to as-built/as-tested conditions.
13. Provide assistance for seasonal or deferred performance testing.
14. Ensure that subcontractors correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
15. Perform all guarantees work for materials furnished under the contract for the time specified in the contract, including all warranties and curing all latent defects within the time period provided in the contract.

1.6 SUBMITTALS

A. Refer also to Specification Section 01 91 13, Subsection 1.8.

B. Provide the CxP a copy of the following items, for the systems to be commissioned:

1. Equipment and System Submittals to include, at a minimum, the following:

   a) Cut sheets
   b) Performance data

2. Manufacturer's pre-startup checklists

   a) Manufacturer's start-up checklist

3. Installation Instructions
4. Shop Drawings (including any resubmittals required by the A/E)
5. Short-circuit analysis and coordination study.
6. Protective device settings
7. Testing plan
8. Completed field test report, including all completed forms and checklists, and list of all outstanding deficiencies and uncompleted items.
9. Operational and maintenance documentation
10. Training plan and training materials
11. As-built documentation

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PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Provide two-way radios, ladders and other equipment as required to complete the commissioning program as outlined in this specification.

B. Provide all safety equipment required for personnel involved in the Commissioning program.

C. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division.

D. All test and measurement instruments shall have been calibrated within the calendar year prior to testing by an independent metrology laboratory using industry standards and methods.

PART 3 - EXECUTION

3.1 MEETINGS

A. Attend as required by section 01 91 13, Subsection 3.1.

3.2 STARTUP, CONSTRUCTION CHECKLISTS, AND INITIAL CHECKOUT

A. Provide as required by section 01 91 13.

B. The subcontractors and vendors shall execute startup and provide the CxP and A/E, through the owner, with a signed and dated copy of the completed startup and construction checklists.

C. Only individuals of the subcontractor (technicians, engineers, tradesmen, vendors, etc.) who have direct knowledge and witnessed that a line-item task on the construction checklist was actually performed shall check off that item. It is acceptable for witnessing supervisors to fill out these forms.

D. The contractor submits the full startup plan to the CxP for review and approval.

E. The CxP reviews and approves the procedures and the format for documenting them, noting any plans that need to be added.

F. Installation Verification

1. General Commissioning Requirements

- Before system start-up begins, the Commission Team shall conduct a final installation verification audit. The Subcontractor shall be responsible for completion of work including change orders and punch list items to the University's satisfaction. The audit shall include, but not be limited to, checking of:
- Piping specialties including balance, control, and isolation valves.

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- Ductwork specialty items including turning devices, balance, fire, smoke, control dampers, and access doors.
- Control sensor types and location.
- Identification of piping, valves, equipment, controls, etc.
- Major equipment, pumps, valves, starters, gauges, thermometers, etc.
- Documentation of prestart-up tests performed, including manufacturer's factory tests.

a) If work is found to be incomplete, incorrect, or non-functional, the Subcontractor shall correct the deficiency before system start-up work proceeds.

G. System Start-Up

1. General Commissioning Responsibilities:

a) A start-up plan shall be developed and submitted by the installing Subcontractor. Start-up plan to include the following:

- Flushing and cleaning of pipe.
- Filters, strainers, and screens.
- Valve/damper positions.
- Electrical tests.
- Pressure tests.
- Safeties.
- Chemical treatment.
- Manufacturer's tests.

b) The start-up plan will be reviewed, and a prestart-up inspection performed by designated members of the Commissioning Team. The installing Subcontractor shall commence with system start-up after approval has been given to start-up plan and the prestart-up inspection is completed. Designated members of the Commissioning Team shall witness system start-up and list system and equipment deficiencies noted during start-up. The Subcontractor shall take corrective action on system deficiencies noted and demonstrate to the Commissioning Team members suitable system operation.

c) Designated systems requiring test and balance work shall have this activity commence after systems have successfully completed start-up. System and equipment deficiencies observed during this activity is to be noted and corrected.

3.3 FUNCTIONAL PERFORMANCE TESTING

A. Provide as required by section 01 91 13.

B. All subcontractor and manufacturer startup and proving tests are to be completed and approved prior to conducting the defined Functional Performance Tests.

C. All associated TAB work and TAB verifications related to a given system shall be completed and approved prior to Functional Performance Testing.

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D. All associated Building Management System (BMS) work and BMS point verifications related to a given system shall be completed and approved prior to Functional Performance Testing for related equipment and systems.

E. Development of Test Procedures

1. Fire Protection testing procedures shall be based on NFPA 3 or manufacturer's testing procedures. The A/E and Sub(s) shall point out to the CxP any specific problems as related to feasibility, safety, equipment, and warranty protection. CxP will observe testing by manufacturers or installing contractors and obtain test reports for inclusion into the Commissioning Final Report.

F. General Commissioning Responsibilities

1. Functional Performance Testing begins after operational testing, adjusting, and balancing of the systems have been completed by the Subcontractors; and the System Description and Hands-on Training sessions have been completed.
2. The objective of the Functional Performance Testing is to advance the building systems from a state of substantial completion to full dynamic operation in accordance with the specified design requirements and design intent.
3. Attaining this object will be accomplished by developing individual systems testing protocols which, when implemented by the Subcontractor, will allow the Commissioning Team to observe, evaluate, identify deficiencies, recommend modifications, tune, and document the systems and systems equipment performance over a range of load and functional levels.
4. Functional Performance tests for the systems to be commissioned are defined in the Commissioning Plan. These tests are intended to be conclusive but may require minor modifications as system operation dictates.

G. Demonstration, Verification and Validation

The fire protection systems demonstration shall include, at minimum, the following:

1. Sprinkler System
2. Fire Alarm System
3. Fire Pump
4. Normal and Emergency Power Operation of all Fire Protection Related Systems
5. Duct Detectors
6. Smoke Detectors
7. Fire Alarm System interlocks with Mechanical Systems (in conjunction with Authority Having Jurisdiction inspection)

3.4 DEFICIENCIES AND NON-CONFORMANCE

A. Provide as required by section 01 91 13.

3.5 DEFERRED TESTING

A. Provide as required by section 01 91 13.

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3.6 TRAINING OF OWNER PERSONNEL

A. Provide training for hardware and major components as specified within Section 01 91 13, 01 79 00, Divisions 21, 22, 23, 26, and in the Commissioning Plan.

B. Coordinate operation and maintenance training activities through the GC.

C. The subcontractor and manufacturers shall provide training. The training sessions provided by the subcontractor shall be customized for this project and reflect all the installed equipment and systems. Training of the materials, components, systems, and equipment shall, at the minimum, incorporate the following items:

1. Materials, components, systems, and equipment
2. Safety precautions and procedures
3. Installation
4. Operational features and functions
5. Operational testing and diagnostics
6. Preventive and predictive maintenance
7. Service: Repair and replacement
8. Operation and Maintenance manual content
9. Testing, adjusting, calibration and balancing.
10. Contractor furnished spare parts and extra materials.
11. Recommended “attic stock” inventory not furnished by contractor.
12. Specialty tool requirements
13. Identification systems
14. Automatic/manual control systems
15. Hazards/Material Safety Data Sheets
16. Cleaning
17. Procurement of replacement parts
18. Warranty reviews including terms and conditions, points of contact, return material procedures, effective date, extended warranty options.
19. Maintenance agreements and similar continuing commitments
20. Reference specification section 01 79 00 for specific requirements.

D. No later than two (2) months following acceptance of equipment and system submittals, the responsible Contractor will submit written training plans to the CxP and Owner for review and approval. There shall be one training plan for each specification section requiring training.

E. Provide Training Plans for all equipment as required in the Division 22 contract specifications.

F. Submit the roster and the completed training plans to the CxP through the GC no later than one (1) week following acceptable completion of the training session.

3.7 OPERATIONS AND MAINTENANCE MANUALS

A. Provide operations and maintenance manuals for hardware and major components as specified within Section 01 78 23, 01 91 13, Divisions 21, 22, 23, 26, and in the Commissioning Plan.

B. Coordinate operation and maintenance submittals through the GC.

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C. CxP Review and Approval. Prior to substantial completion, the CxP shall review the operations and maintenance manuals, documentation and redline as-builts for systems that were commissioned to verify compliance with the specifications. The CxP will communicate deficiencies in the manuals to the owner. This work does not supersede the A/E team's review of the operations and maintenance manuals according to the A/E contract.

END OF SECTION 21 08 00

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SECTION 21 13 13

FIRE PROTECTION PIPING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Specialty valves and connections.
3. Sprinklers.
4. Standpipes.
5. Alarm devices.
6. Pressure gauges.

1.3 DEFINITIONS

A. Standard-Pressure Piping: System piping designed to operate at working pressure of 175-psig maximum.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For standpipe systems, sprinkler systems, and fire pump systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

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1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Plumbing piping.
2. HVAC piping.
3. Items penetrating finished ceiling include the following:

a. Lighting fixtures.
b. Air outlets and inlets.

B. Qualification Data: For qualified Installer.

C. Approved Sprinkler Piping Drawings: Working plans, prepared by Nicet IV according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

1. Sprinklers shall be referred to on drawings and shall be specifically identified by the listed manufacturer's style or series designation. Trade names and abbreviations are not permitted.

D. Grooved joint products shall be shown on drawings and product submittals and shall be specifically identified with the applicable Victaulic style or series number.

E. Fire-hydrant flow test report.

F. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

G. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wet-pipe sprinkler systems and specialties to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

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1.8 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility (Nicet IV). Base calculations on results of fire-hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

1. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13.

B. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:

1. Main Level: HAMV - Fire Main Equipment.

a. Level 1: HCBZ - Indicator Posts, Gate Valve.
b. Level 1: HLOT - Valves.

1) Level 3: HLUG - Ball Valves, System Control.
2) Level 3: HLXS - Butterfly Valves.
3) Level 3: HMER - Check Valves.
4) Level 3: HMRZ - Gate Valves.

2. Main Level: VDGT - Sprinkler System & Water Spray System Devices.

a. Level 1: VQGU - Valves, Trim and Drain.

C. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:

1. Automated Sprinkler Systems:

a. Indicator posts.
b. Valves.

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1) Gate valves.
2) Check valves.

a) Single check valves.

3) Miscellaneous valves.

D. Source Limitations for Valves: Obtain valves for each valve type from a single manufacturer.

E. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B1.20.1 for threads for threaded-end valves.
3. ASME B31.9 for building services piping valves.

F. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

G. NFPA Compliance: Comply with NFPA 24 for valves.

H. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher as required by system pressures.

I. Valve Sizes: Same as upstream piping unless otherwise indicated.

J. Standard-Pressure, Fire-Suppression Standpipe System Component: Listed for 175-psig minimum working pressure.

K. Fire-suppression standpipe design shall be approved by authorities having jurisdiction.

1. Minimum residual pressure at each hose-connection outlet is as follows:

a. NPS 2-1/2 Hose Connections: 100 psig.

2. Available fire-hydrant flow test records indicate the following conditions:

a. Date: February 17, 2023
b. Time: -
c. Performed by: Town of Smyrna
d. Location of Residual Fire Hydrant R: 15 Cooke Avenue; Hydrant 489
e. Static Pressure at Residual Fire Hydrant R: 53 PSI
f. Measured Flow at Flow Fire Hydrant F: 1350 GPM
g. Residual Pressure at Residual Fire Hydrant R: 48 PSI

3. The sprinkler system design shall be approved by authorities having jurisdiction.

a. Margin of Safety for Available Water Flow and Pressure: Include a 10 percent safety factor for losses, include losses through water-service piping, valves, and backflow preventers.

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2.2 STEEL PIPE AND FITTINGS

A. Standard-Weight, Galvanized- and Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 10, Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

C. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.

D. Steel Couplings: ASTM A 865/A 865M, threaded.

E. Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

F. Malleable- or Ductile-Iron Unions: UL 860.

G. Cast-Iron Flanges: ASME 16.1, Class 125.

H. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or EPDM rubber gasket.

a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.

2. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.

I. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.

1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

J. Grooved-Joint, Steel-Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Victaulic Company.
2) Tyco Fire & Building Products LP.
3) Anvil International.
4) Approved Equal.

2. Pressure Rating: 175-psig minimum.
3. Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting, with dimensions matching steel pipe. Short-pattern in applicable sizes, with flow equal to standard pattern fittings.
4. AWWA C606 and UL 213 cover couplings in "Grooved-End-Pipe Couplings for Steel Piping" Subparagraph below in NPS 3/4 to at least NPS 12.

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5. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and ATSM 449 compliant bolts and nuts.

    a. Rigid: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with NFPA-13, fully installed at visual pad-to-pad offset contact. Couplings that require gapping of bolt pads or specific torque ratings for proper installation are not permitted. Installation-Ready, for direct stab installation without field disassembly. Basis of Design: Victaulic Style 009N, 109 or 107N.
    b. Flexible: Use in locations where vibration attenuation and stress relief are required. Basis of Design: Victaulic Style 177 Installation-Ready, and Style 77.

6. Installation-Ready fittings for Schedule 10 grooved end steel piping in fire protection applications sizes NPS 1-¼ thru 2½. Fittings shall consist of a ductile iron housing conforming to ASTM A-536, Grade 65-45-12, with Installation-Ready ends, orange enamel coated. Fittings complete with prelubricated Grade "E" EPDM Type 'A' gasket; and ASTM A449 electroplated steel bolts and nuts. System shall be UL listed for a working pressure of 300 psi and FM approved for working pressure 365 psi.

2.3 CPVC PIPE AND FITTINGS

A. CPVC Pipe: ASTM F 442/F 442M and UL 1821, SDR 13.5, for 175-psig rated pressure at 150 deg F, with plain ends. Include "LISTED" and "CPVC SPRINKLER PIPE" markings.

B. CPVC Fittings: UL listed and FM Global approved, for 175-psig rated pressure at 150 deg F, socket type. Include "LISTED" and "CPVC SPRINKLER FITTING" markings.

1. NPS 3/4 to NPS 1-1/2: ASTM F 438 and UL 1821, Schedule 40, socket type.
2. NPS 2 to NPS 3: ASTM F 439 and UL 1821, Schedule 80, socket type.
3. CPVC-to-Metal Transition Fittings: CPVC, one piece, with dimensions equivalent to pipe; one end with threaded brass insert, and one socket end.
4. CPVC-to-Metal Transition Unions: CPVC, with dimensions equivalent to pipe; one end with threaded brass insert, and one socket end.
5. Flanges: CPVC, one or two pieces.

C. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493 solvent cement recommended by pipe and fitting manufacturer and made for joining CPVC sprinkler pipe and fittings. Include cleaner or primer recommended by pipe and fitting manufacturer.

1. Use solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Use adhesive primer that has a VOC content of 650 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Plastic Pipe-Flange Gasket and Bolts and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

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2.4 YARD TYPE FIRE-DEPARTMENT CONNECTION

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Fire-End & Croker Corporation
2. Guardian Fire Equipment, Inc.
3. Potter Roemer LLC.
4. Approved Equal.

B. Standard: UL 405.

C. Type: Exposed, freestanding.

D. Pressure Rating: 300 psig.

E. Body Material: Corrosion-resistant metal.

F. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.

G. Caps: Brass, lugged type, with gasket and chain.

H. Escutcheon Plate: Round, brass, floor type.

I. Outlet: Bottom with pipe threads.

J. Number of Inlets: As determined by Authorities Having Jurisdiction.

K. Sleeve: Brass.

L. Sleeve Height: 18 inches.

M. Escutcheon Plate Marking: Similar to “AUTO SPKR & STANDPIPE”.

N. Finish: Polished chrome plated including sleeve.

O. Outlet Size: NPS 6.

2.5 HOSE CONNECTIONS

A. Nonadjustable-Valve Hose Connections:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Tyco Fire & Building Products LP.
b. Fire-End & Croker Corporation.
c. Potter Roemer LLC.
d. Viking Corporation.

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e. Approved Equal.

2. Standard: UL 668 hose valve for connecting fire hose.
3. Pressure Rating: 300 psig minimum.
4. Material: Brass or bronze.
5. Size: NPS 1-1/2 or NPS 2-1/2, as indicated.
6. Inlet: Female pipe threads.
7. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
8. Pattern: Angle or gate.
9. Finish: Rough chrome-plated.

2.6 ESCUTCHEONS

A. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

2.7 SPECIALTY VALVES

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating:

1. Standard-Pressure Piping Specialty Valves: 175-psig minimum.
2. High-Pressure Piping Specialty Valves: 300-psig.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

2.8 PRESSURE REDUCING VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Guardian Fire Equipment, Inc.
2. Fire-End & Croker Corporation.
3. Tyco Fire & Building Products LP.
4. Viking Corporation.
5. Approved Equal.

B. Description:

1. UL Listed
2. Pressure Rating: 300 psig minimum.
3. Material: Ductile Iron ASTM 65-45-12.
4. Seat: Stainless Steel

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5. Spring: Stainless steel
6. Elastomers: Buna-N
7. Pilot: Brass Body with stainless steel internals
8. Inlet: Flanged or grooved.
9. Outlet: Flanged or grooved.
10. Pattern: Globe.
11. Finish: Fused epoxy.

2.9 TWO-PIECE BALL VALVES WITH INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Victaulic.
2. Ames.
3. Elkhart Brass Mfg. Co., Inc.
4. Approved Equal.

B. Description:

1. UL 1091, except with ball instead of disc and FM Global standard for indicating valves (ball type), Class Number 1112.
2. Minimum Pressure Rating: 175 psig.
3. Body Design: Two piece.
4. Body Material: Forged brass or bronze.
5. Port Size: Full or standard.
6. Seats: PTFE.
7. Stem: Bronze or stainless steel.
8. Ball: Chrome-plated brass.
9. Actuator: Worm gear or traveling nut.
10. Supervisory Switch: Internal or external.
11. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
12. End Connections for Valves NPS 2-1/2: Grooved ends.

2.10 IRON BUTTERFLY VALVES WITH INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Basis of Design: Victaulic Company.
2. Upon approval of the engineer:

    a. Victaulic Company.
    b. Tyco Fire & Building Products LP.
    c. NIBCO INC.
    d. Viking Corporation.

B. Description:

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1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
2. Minimum Pressure Rating: 300 psig.
3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
4. Seat Material: Pressure-responsive EPDM.
5. Stem: Stainless steel, offset from the disc centerline to provide complete 360-degree circumferential seating.
6. Disc: Ductile iron, and EPDM or SBR coated.
7. Actuator: Weatherproof actuator housing with worm gear or traveling nut.
8. Supervisory Switch: Internal or external.
9. Body Design: Lug or wafer Grooved-end connections.
10. Basis of Design: Victaulic Series 705.

2.11 CHECK VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Victaulic Company.
   b. Tyco Fire & Building Products LP.
   c. NIBCO INC.
   d. Viking Corporation.
   e. Approved Equal.

B. Description:

1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 175 psig.
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded.
10. Basis of Design: Victaulic Series 717.

2.12 BRONZE OS&Y GATE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Milwaukee Valve Company.
2. Tyco Fire & Building Products LP.
3. NIBCO INC.
4. Approved Equal.

B. Description:

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1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Bronze or brass.
4. Wedge: One-piece bronze or brass.
5. Wedge Seat: Bronze.
6. Stem: Bronze or brass.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Threaded.

2.13 IRON OS&Y GATE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Victaulic Company.
b. Tyco Fire & Building Products LP.
c. NIBCO INC.
e. Approved Equal.

B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze.
5. Wedge Seat: Cast or ductile iron, or bronze.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged, Grooved, or Threaded.
10. Basis of Design: Victaulic Series 771.

2.14 NRS GATE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Victaulic
b. Tyco Fire & Building Products LP.
c. NIBCO INC.
d. Approved Equal.

B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).

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2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron.
5. Wedge Seat: Cast or ductile iron, or bronze.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged, Grooved, or Threaded.
10. Basis of Design: Victaulic Series 772.

2.15 TRIM AND DRAIN VALVES

A. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Victaulic Company.
    b. Tyco Fire & Building Products LP.
    c. Fire Protection Products, Inc.
    d. Fire-End & Croker Corporation.
    e. Potter Roemer LLC.
    f. Approved Equal.

2. Description:

    a. Body Design: Two piece.
    b. Body Material: Forged brass or bronze.
    c. Port size: Full or standard.
    d. Seats: PTFE.
    e. Stem: Bronze or stainless steel.
    f. Ball: Chrome-plated brass.
    g. Actuator: Handlever.
    h. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
    i. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.

B. Alarm Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Victaulic
    b. Reliable Automatic Sprinkler Co., Inc. (The).
    c. Viking Corporation.
    d. Tyco Fire & Building Products LP.
    e. Approved Equal.

2. Standard: UL 193.
3. Design: For horizontal or vertical installation.
4. Valve internal components shall be replaceable with valve in the installed position.

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5. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gauges, retarding chamber, and fill-line attachment with strainer.
6. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
7. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
9. Basis of Design: Victaulic Series 751.

C. Pre-Assembled Fire Protection Valves

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Victaulic Company.
    b. Tyco Fire & Building Products LP.
    c. Approved Equal.

2. Type: Pre-assembled Dry valve, mounted in a steel cabinet with red ASA-61 electrostatically applied polyester powder coating.

    a. Cabinet shall have field removable access panels on three sides to allow for ease of valve maintenance, servicing, and installation.

3. UL listed and FM approved, with all materials and wiring conforming to NFPA requirements.
4. Provided with a Series 728 ball valve or Series 705 butterfly shutoff valve with pre-wired supervisory switches, the sprinkler system fire protection valve, alarm line pressure switches, air supervisory pressure switches, alarm pressure switch and pressure gauges for proper operation.
5. All external electrical connections shall be able to be connected through a factory provided conduit connection to an enclosure inside of the cabinet.
6. Water inlet, system supply, and drain connections shall be grooved for ease of installation.
7. 300 psi pressure rating.
8. Basis of Design: Victaulic FireLock® Series 745 Fire-Pac.

D. Pressure-Reducing Hose Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Tyco Fire & Building Products LP.
    b. Viking Corporation.
    c. Approved Equal.

2. UL 668 hose valve, with integral UL 1468 reducing device.
3. Pressure Rating: 300 psig minimum.
4. Material: Brass or bronze.
5. Inlet: Female pipe threads.
6. Outlet: Threaded with or without adapter having male hose threads.
7. Pattern: Angle or gate.
8. Finish: Polished chrome-plated.

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E. Automatic (Ball Drip) Drain Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Reliable Automatic Sprinkler Co., Inc. (The).
   b. Tyco Fire & Building Products LP.
   c. Viking Corporation.
   d. Approved Equal.

2. Standard: UL 1726.
3. Pressure Rating: 175-psig minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4.
6. End Connections: Threaded.

2.16 PIPING SPECIALTIES

A. Branch Outlet Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Victaulic
   b. Anvil International.
   c. National Fittings, Inc.
   d. Tyco Fire & Building Products LP.
   e. Approved Equal.

2. Standard: UL 213.
3. Pressure Rating: 175-psig minimum.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-tee and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.
9. Basis of Design: Victaulic Style 920 / 920N.

B. Flow Detection and Test Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Victaulic
   b. AGF Manufacturing Inc.
   c. Reliable Automatic Sprinkler Co., Inc.
   d. Viking Corporation
   e. Tyco Fire & Building Products LP.

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f. Approved Equal.

2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 175-psig minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded or grooved.

C. Branch Line Testers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Elkhart Brass Mfg. Co., Inc.
b. Fire-End & Croker Corporation.
c. Potter Roemer LLC.
d. Tyco Fire & Building Products LP.
e. Approved Equal.

2. Standard: UL 199.
3. Pressure Rating: 175 psig.
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Tyco Fire & Building Products LP.
b. Victaulic Company.
c. Viking Corporation.
d. Approved Equal.

2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 175-psig minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aegis Technologies, Inc.
b. CECA, LLC.

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c. Corcoran Piping System Co.
d. Merit Manufacturing
e. Tyco Fire & Building Products LP.
f. Approved Equal.

2. Standard: UL 1474.
3. Pressure Rating: 250-psig minimum.
4. Body Material: Steel pipe with EPDM-rubber O-ring seals.
5. Size: Same as connected piping.
6. Length: Adjustable.
7. Inlet and Outlet: Threaded.

2.17 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Basis of Design: Victaulic Company.
2. Upon approval of the engineer:

a. Victaulic
b. Reliable Automatic Sprinkler Co., Inc.
c. Tyco Fire & Building Products LP.
d. Viking Corporation.

B. Sprinklers shall be glass bulb type, with hex shaped wrench boss integrally cast into the sprinkler body to reduce the risk of damage during installation. (Wrenches shall be provided by the sprinkler manufacturer that directly engage the cast wrench boss.)

C. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

D. Pressure Rating for Residential Sprinklers: 175-psig maximum.

E. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

F. Automatic Sprinklers with Heat-Responsive Element:

1. Nonresidential Applications: UL 199.
2. Residential Applications: UL 1626.
3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

G. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Chrome-plated steel, two piece, with 1-inch vertical adjustment.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

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H. Sprinkler Guards:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Reliable Automatic Sprinkler Co., Inc. (The).
b. Tyco Fire & Building Products LP.
c. Victaulic Company.
d. Viking Corporation.
e. Approved Equal.

2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

I. Escutcheons and guards shall be listed and supplied for use with the sprinkler by the sprinkler manufacturer.

2.18 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Electrically Operated Alarm Bell:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Tyco Fire & Building Products LP.
b. Notifier.
c. Potter Electric Signal Company, LLC.
d. Approved Equal.

2. Standard: UL 464.
3. Type: Vibrating, metal alarm bell.
4. Size: 6-inch minimum- diameter.
5. Finish: Red-enamel factory finish, suitable for outdoor use.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application

C. Water-Flow Indicators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Potter Electric Signal Company, LLC.
b. Tyco Fire & Building Products LP.
c. Viking Corporation.
d. Approved Equal.

2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.

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4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.
6. Pressure Rating: 250 psig.
7. Design Installation: Horizontal or vertical.

D. Pressure Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Potter Electric Signal Company, LLC.
    b. Tyco Fire & Building Products LP.
    c. Viking Corporation.
    d. Approved Equal.

2. Standard: UL 346.
3. Type: Electrically supervised water-flow switch with retard feature.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design Operation: Rising pressure signals water flow.

E. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Fire-Lite Alarms, Inc.; a Honeywell International company.
    b. Kennedy Valve Company; a division of McWane, Inc.
    c. Potter Electric Signal Company, LLC.
    d. Tyco Fire & Building Products LP.
    e. Approved equal.

2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Indicator-Post Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Potter Electric Signal Company, LLC.
    b. Tyco Fire & Building Products LP.
    c. Approved equal.

2. Standard: UL 346.

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3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled indicator-post valve is in other than fully open position.

2.19 PRESSURE GAUGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ashcroft Inc.
2. Viking Corporation.
3. Tyco Fire & Building Products LP.
4. Approved Equal.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gage Range: 0 to 300 psig.

E. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to water-service piping for service entrance to building.

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping.

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.

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1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.

C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

G. Install sprinkler piping with drains for complete system drainage.

H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

I. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

J. Install alarm devices in piping systems.

K. Furnish and install air release valve(s) at the high point(s) on the fire sprinkler system piping to assure evacuation of air from the system during and after filling. The automatic air release valve shall consist of a 40 mesh “Y” type strainer connected to an automatic air vent valve. The output of the air vent valve shall be a ½” NPT male connection which allows a drain attachment for safely draining inadvertent discharge. Install drain pipe to appropriate location. The air vent assembly shall be field replaceable without disabling the sprinkler system by the installation of a ½” ball valve installed before the Y strainer for isolation purposes. The automatic air release valve shall be mounted in a vertical position and shall require a minimum of 8 ” of clearance above the fire sprinkler main or branch line piping.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

M. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gauges with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gauges to permit removal and install where they are not subject to freezing.

N. Pressurize and check sprinkler system piping.

O. Fill sprinkler system piping with water.

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P. Install sleeves for piping penetrations of walls, ceilings, and floors.

Q. Install sleeve seals for piping penetrations of concrete walls and slabs.

R. Install escutcheons for piping penetrations of walls, ceilings, and floors.

S. Install drain valves on standpipes. Extend drain piping to outside of building.

T. Install alarm devices in piping systems.

U. Install hangers and supports for standpipe system piping according to NFPA 14. Comply with requirements in NFPA 13 for hanger materials.

V. Install pressure gauges on riser or feed main and at top of each standpipe. Include pressure gauges with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gauges to permit removal and install where they are not subject to freezing.

W. Fill wet-type standpipe system piping with water.

3.4 HOSE-CONNECTION INSTALLATION

A. Install hose connections adjacent to standpipes.

B. Install freestanding hose connections for access and minimum passage restriction.

C. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

D. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

3.5 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

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F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

I. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints. Install in accordance with the manufacturer's latest published installation instructions. Pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to (and including) groove. Gasket shall be manufactured by the coupling manufacturer and verified as suitable for the intended service. A factory trained representative (direct employee) of the coupling manufacturer shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation. The representative shall periodically visit the job site and review installation to ensure best practices in grooved joint installation are being followed. Contractor shall remove and replace any improperly installed products.

J. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

K. Plastic-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

3.6 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

NOT FOR BIDDING PURPOSES

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Examine grooved ends for form and cleanliness. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.

F. Do not attempt to repair defective valves; replace them with new valves.

3.7 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

A. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

B. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

C. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above the pipe center.

E. Install valves in position to allow full stem movement.

F. Install valve tags. Comply with NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

G. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.

H. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

3.8 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

NOT FOR BIDDING PURPOSES

1. Install valves in vertical position for proper direction of flow, in main supply to system.
2. Install alarm valves with bypass check valve and retarding chamber drain-line connection.

3.9 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.

B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

C. Do not install sprinklers that have been dropped, damaged, or show a visible loss of fluid. Never install sprinklers with cracked bulbs.

D. Sprinkler bulb protector shall be removed by hand after installation. Do not use tools or any other device(s) to remove the protector that could damage the bulb in any way.

3.10 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.11 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Coordinate with fire-alarm tests. Operate as required.
6. Coordinate with fire-pump tests. Operate as required.
7. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.12 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

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3.13 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves and pressure-maintenance pumps.

3.14 PIPING SCHEDULE

A. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends, cast-iron threaded fittings, and joints.

B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

C. CPVC pipe, Schedule 40 CPVC fittings, and solvent-cemented joints may be used for light-hazard residential occupancies down stream of floor control valve assemblies on residential floors only.

D. Standard-pressure NPS 2 and smaller, shall be one of the following:

1. Standard-weight schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Piping 2" may be standard weight schedule 40, black steel with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

E. Standard-pressure, NPS 2-1/2 to NPS 8, shall be the following:

1. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.15 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Concealed sprinklers.
3. Wall Mounting: Sidewall Concealed sprinklers.
4. Spaces Subject to Freezing: Upright sprinklers.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
2. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
3. Upright or Pendent Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to chemicals, or other corrosive fumes.

END OF SECTION 21 13 13

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SECTION 21 29 33

CONTROLLERS FOR FIRE PUMP DRIVERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Full-service, reduced-voltage controllers rated 600 V and less.
2. Controllers for pressure-maintenance pumps.

1.3 DEFINITIONS

A. ATS: Automatic transfer switch.

B. NO: Normally open.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type of product indicated.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Show tabulations of the following:

a. Each installed unit's type and details.
b. Enclosure types and details for types other than NEMA 250, Type 2.
c. Factory-installed devices.
d. Nameplate legends.
e. Short-circuit current (withstand) rating of integrated unit.
f. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.
g. Specified modifications.

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4. Include diagrams for power, signal, alarm, control wiring, and pressure-sensing tubing.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Product Certificates: For each type of product indicated from the manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product indicated to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
2. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor-based logic controls.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of an NRTL.

B. Source Limitations: Obtain fire-pump controllers and all associated equipment from single source or producer.

1.8 FIELD CONDITIONS

A. Interruption of Existing Electric Service: Notify Construction Manager no fewer than seven days in advance of proposed interruption of electric service and comply with NFPA 70E.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 20 and NFPA 70.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

NOT FOR BIDDING PURPOSES

2.2 FULL-SERVICE CONTROLLERS FOR ELECTRIC DRIVEN FIRE PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Tornatech.
2. Eaton.
3. Joslyn Clark Corporation.
4. Approved Equal.

B. General Requirements for Full-Service Controllers:

1. Comply with NFPA 20 and UL 218.
2. Combined automatic and nonautomatic operation.
3. Factory assembled, wired, and tested; continuous-duty rated and service entrance rated

C. Method of Starting:

1. Pressure-switch actuated.

a. Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
b. System pressure recorder, electric ac driven, with spring backup.
c. Programmable minimum-run-time relay to prevent short cycling.
d. Programmable timer for weekly tests.

2. Magnetic Controller: Reduced voltage electronic “Soft Start” type.
3. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contactor independent of all electric or pressure actuators.

D. Method of Stopping: Automatic and nonautomatic shutdown after automatic starting.

E. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at controller location.

F. Method of Isolation and Overcurrent Protection: Interlocked isolating switch and nonthermal MCCB; with a common, externally mounted operating handle, and providing locked-rotor protection.

G. Door-Mounted Operator Interface and Controls:

1. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
2. Method of Control and Indication:

a. Microprocessor-based logic controller, with multiline digital readout.
b. Membrane keypad.
c. LED alarm and status indicating lights.

3. Local and Remote Alarm and Status Indications:

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a. Controller power on.
b. Motor running condition.
c. Loss-of-line power.
d. Line-power phase reversal.
e. Line-power single-phase condition.

4. Audible alarm, with silence push button.
5. Nonautomatic START and STOP push buttons or switches.

H. Optional Features:

1. Extra Output Contacts:

a. One NO set of contacts for motor running condition.
b. One set of contacts for loss-of-line power.

2. Local alarm bell.
3. Door-mounted thermal or impact printer for alarm and status logs.
4. Operator Interface Communications Ports: USB, Ethernet, and RS485.

I. ATS:

1. Complies with NFPA 20, UL 218, and UL 1008.
2. Integral with controller as a listed combination fire-pump controller and power transfer switch.
3. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
4. Allows manual transfer from one source to the other.
5. Alternate-Source Isolating and Disconnecting Means: Integral molded-case switch, with an externally mounted operating handle.
6. Alternate-Source Isolating and Disconnecting Means: Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker shall be provided with nonthermal sensing, instantaneous-only short-circuit overcurrent protection to comply with available fault currents.
7. Local and Remote Alarm and Status Indications:

a. Normal source available.
b. Alternate source available.
c. In normal position.
d. In alternate position.
e. Isolating means open.

8. Audible alarm, with silence push button.
9. Nonautomatic (manual, nonelectric) means of transfer.
10. Engine test push button.
11. Start generator output contacts.
12. Timer for weekly generator tests.

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2.3 CONTROLLERS FOR PRESSURE-MAINTENANCE PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Tornatech.
2. Eaton.
3. Hubbell Incorporated.
4. Joslyn Clark Corporation.
5. Approved Equal.

B. General Requirements for Pressure-Maintenance-Pump Controllers:

1. Type: UL 508, factory-assembled, -wired, and -tested, across-the-line controller; for combined automatic and manual operation.
2. Enclosure: UL 508 and NEMA 250, Type 2 for wall-mounting.
3. Factory assembled, wired, and tested.
4. Finish: Manufacturer's standard color paint.

C. Rate controller for scheduled horsepower and include the following:

1. Fusible disconnect switch.
2. Pressure switch.
3. Hand-off-auto selector switch.
4. Pilot light.
5. Running period timer.

2.4 ENCLOSURES

A. Fire-Pump Controllers and ATS, NEMA 250, to comply with environmental conditions at installed locations and NFPA 20.

1. Indoor, Dry and Clean Locations: Type 1 (IEC IP10).

B. Enclosure Color: Manufacturer's standard "fire-pump-controller red".

C. Nameplates: Comply with NFPA 20; complete with capacity, characteristics, approvals, listings, and other pertinent data.

D. Optional Features:

1. Floor stands, 12 inches high, for floor-mounted controllers.

2.5 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire-pump controllers according to requirements in NFPA 20 and UL 218.

1. Verification of Performance: Rate controllers according to operation of functions and features specified.

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B. Fire-pump controllers will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive equipment, with Installer present, for compliance with requirements and other conditions affecting performance.

B. Examine equipment before installation. Reject equipment that is wet or damaged by moisture or mold.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROLLER INSTALLATION

A. Coordinate installation of controllers with other construction including conduit, piping, fire-pump equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels. Ensure that controllers are within sight of fire-pump drivers.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Install controllers within sight of their respective drivers.

D. Connect controllers to their dedicated pressure-sensing lines.

E. Floor-Mounting Controllers: Install controllers on concrete bases, using floor stands high enough so that the bottom of enclosure cabinet is not less than 12 inches above finished floor.

1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
3. Install anchor bolts to elevations required for proper attachment to supported equipment.

F. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

G. Comply with NEMA ICS 15.

3.3 POWER WIRING INSTALLATION

A. Install power wiring between controllers and their services or sources, and between controllers and their drivers. Comply with requirements in NFPA 20, NFPA 70, and Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

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3.4 CONTROL AND ALARM WIRING INSTALLATION

A. Install wiring between controllers and remote devices and facility's central monitoring system. Comply with requirements in NFPA 20 and NFPA 70.

B. Install wiring between controllers and the building's fire-alarm system.

C. Bundle, train, and support wiring in enclosures.

D. Connect remote manual and automatic activation devices where applicable.

3.5 IDENTIFICATION

A. Comply with requirements in NFPA 20 for marking fire-pump controllers.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification in NFPA 20.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

D. Acceptance Testing Preparation:

1. Inspect and Test Each Component:

   a. Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
   b. Test insulation resistance for each element, component, connecting supply, feeder, and control circuits.
   c. Test continuity of each circuit.

2. Verify and Test Each Electric-Drive Controller:

   a. Verify that voltages at controller locations are within plus 10 or minus 1 percent of motor nameplate rated voltages, with motors off. If outside this range for any motor, notify Construction Manager before starting the motor(s).
   b. Test each motor for proper phase rotation.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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E. Field Acceptance Tests:

1. Do not begin field acceptance testing until suction piping has been flushed and hydrostatically tested and the certificate for flushing and testing has been submitted to Construction Manager and authorities having jurisdiction.
2. Prior to starting, notify authorities having jurisdiction of the time and place of the acceptance testing.
3. Engage manufacturer's factory-authorized service representative to be present during the testing.
4. Perform field acceptance tests as outlined in NFPA 20.

F. Controllers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup according to manufacturer's written instructions.

3.8 ADJUSTING

A. Adjust controllers to function smoothly and as recommended by the manufacturer.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, and timers.

C. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

D. Set field-adjustable pressure switches.

3.9 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.

B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

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3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controllers, and to use and reprogram microprocessor-based controls within this equipment.

END OF SECTION 21 29 33

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SECTION 21 31 13

FIRE PROTECTION FIRE PUMP SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Vertical In-Line, single-stage with electric motor drive fire pumps.
2. Fire-pump accessories and specialties.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of fire pump, from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire pumps to include in operation and maintenance manuals.

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PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 20.

B. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

C. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig minimum unless higher pressure rating is indicated.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 GENERAL REQUIREMENTS FOR CENTRIFUGAL FIRE PUMPS

A. Description: Factory-assembled and -tested fire-pump and driver unit.

B. Base: Fabricated and attached to fire-pump and driver unit, with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.

C. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

2.3 VERTICAL INLINE, SINGLE-STAGE, FIRE PUMP WITH ELECTRIC MOTOR DRIVE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Peerless Pump Company.
2. A-C Fire Pump; a Xylem brand.
3. PACO Pumps; Grundfos Pumps Corporation, USA
4. Aurora Pump; Pentair Ltd
5. Approved Equal.

B. Pump:

1. Standard: UL 448, for vertical single stage for fire service.
2. Casing: Cast iron with pipe-flange connections.
3. Impeller: Bronze, single suction type.
4. Wear Rings: Replaceable bronze.
5. Shaft and Sleeve: Steel shaft with bronze shaft sleeve.

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a. Seals: Packed stuffing box with 304 stainless steel glands.

6. Mounting: Pump and driver on same cast iron base.

C. Driver:

1. Standard: UL 1004A.
2. Type: Electric motor; NEMA MG 1, polyphase Design B.

D. Capacities and Characteristics:

1. Refer to the fire pump specification and schedule on the drawings.

2.4 FIRE-PUMP ACCESSORIES AND SPECIALTIES

A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.

B. Circulation Relief Valves: UL 1478, brass, spring loaded; for installation in pump discharge piping.

C. Relief Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. CLA-VAL Automatic Control Valves.
b. Kunkle Valve.
c. OCV Control Valves.
d. Approved Equal.

2. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.

D. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.

E. Outlet Fitting: Concentric tapered reducer at pump discharge outlet.

F. Discharge Cone: Closed or open type.

G. Hose Valve Manifold Assembly:

1. Standard: Comply with requirements in NFPA 20.
2. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel, with ends threaded according to ASME B1.20.1.
3. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
4. Automatic Drain Valve: UL 1726.
5. Manifold:

a. Test Connections: Comply with UL 405; however, provide outlets without clappers instead of inlets.

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b. Body: Flush type, brass, or ductile iron, with number of outlets required by NFPA 20.
c. Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe, with ends threaded according to ASME B1.20.1.
d. Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
e. Escutcheon Plate: Brass or bronze; rectangular.
f. Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
g. Exposed Parts Finish: chrome plated.
h. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

2.5 REGENERATIVE TURBINE, PRESSURE-MAINTENANCE PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. A-C Fire Pump; a Xylem brand.
2. Aquarius Fluid Products, Inc.
3. Aurora Pump; Pentair Ltd.
4. Crane Pumps & Systems.
5. MTH Pumps/MTH Tool Company, Inc.
6. PACO Pumps; Grundfos Pumps Corporation, USA.

B. Description: Factory-assembled and -tested, close-coupled, single-stage, regenerative-turbine centrifugal pump as defined in HI 1.1-1.2 and HI 1.3; with pump and motor mounted horizontally.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded inlet and outlet.
2. Impeller: Bronze, balanced, and keyed to shaft.
3. Pump Shaft: Stainless steel with deflector.
4. Shaft Sleeve: Bronze.
5. Seal: Mechanical type with spring-loaded rotating head.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Motor: Single speed with permanently lubricated ball bearings and rigidly mounted to pump head.

F. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet long.

G. Nameplate: Permanently attached to pump and indicating capacity and characteristics.

H. Capacities and Characteristics:

1. Refer to the vertical pressure pump specification and schedule on the drawings.

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2.6 GROUT

A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink and recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.7 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."

1. Verification of Performance: Rate fire pumps according to UL 448.

B. Fire pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment bases and anchorage provisions, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of fire pumps.

B. Examine roughing-in for fire-suppression piping systems to verify actual locations of piping connections before fire-pump installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.

B. Equipment Mounting:

1. Install fire pumps on cast-in-place concrete equipment bases.

C. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.

D. Support piping and pumps separately, so weight of piping does not rest on pumps.

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E. Install valves that are same size as connecting piping.

F. Install pressure gauges on fire-pump suction and discharge flange pressure-gauge tappings.

G. Install piping hangers and supports, anchors, valves, gauges, and equipment supports according to NFPA 20.

H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

I. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

33. ALIGNMENT

A. Align split-case pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.

B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.

C. Align piping connections.

D. Align pump and driver shafts for angular and parallel alignment according to tolerances specified by manufacturer.

3.4 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps and equipment to allow service and maintenance.

C. Connect relief-valve discharge to drainage piping or point of discharge.

D. Connect fire pumps to their controllers.

3.5 IDENTIFICATION

A. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.6 FIELD QUALITY CONTROL

A. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Section 212933 "Controllers for Fire-Pump Drivers."

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B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. After installing components, assemblies, and equipment, including controller, test for compliance with requirements.
2. Test according to NFPA 20 for acceptance and performance testing.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

F. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup according to the manufacturer's written instructions.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 21 31 13

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SECTION 22 00 00

GENERAL REQUIREMENTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Division 01 Specifications, General and Supplemental Requirements apply to this section with additions and modifications specified herein.

B. Instructions to Bidders, Bidding Forms, Forms of Agreement between Owner and Contractor, Contract Award Date, Starting and Completion Dates, Conditions of the Contract, Insurance Requirements, and other Owner Requirements will be furnished separately by the Owner. These documents, as well as any addenda issued, shall form a part of these Specifications, and this Contractor shall consult them in detail for instructions pertaining to their work.

C. Each trade contractor shall receive all drawings and specification sections issued as part of the overall bid package. All contractors are to receive, review, and coordinate all of their work as shown or referenced on the other trade documents. All work shown or referenced on the other trade documents shall be included as part of the overall project scope for that particular discipline and trade.

1.2 SCOPE OF WORK:

A. These specifications and accompanying drawings are intended to cover the furnishing of all labor, material, and equipment and superintendence of the Plumbing System for this project. They are also intended to cover performing all miscellaneous operations including excavations and backfilling, cutting, channeling, chasing, and patching necessary for the installation of the plumbing systems, as shown on the drawings, as hereinafter specified, as directed by the Engineer, or as may be required for a complete and fully functional Plumbing installation.

B. It is the intent and purpose of these specifications and accompanying drawings to cover and include each item, all materials, machinery, apparatus, and labor necessary to properly install, equip, adjust, and put into perfect operation the respective portions of the installations specified and to so interconnect the various items or sections of the work as to form a complete and properly operating whole.

C. Drawings and specifications have been prepared with best knowledge of conditions available at the time of design and are intended to be complementary. What is called for by one shall be as binding as if called for by both. Where conflicts occur between drawings and specifications, or between the Plumbing documents and the documents of other disciplines, the situation shall be brought to the attention of the Design Professional before the work in question is installed. In case of conflict between provisions of the Specifications or between the drawings and the specifications, the more stringent requirement shall govern. Where a requirement is applied to a specific product, condition, system or Specification Section which conflicts with a more general requirement elsewhere, the specific shall supersede the general. If any obscurities or

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discrepancies exist, they shall be brought to the attention of the Design Professional before bids are submitted. If they are not discovered before bids are submitted, the Design Professional shall be notified and shall render a decision. This decision shall be final.

D. Any equipment, apparatus, machinery, material, and small items not mentioned in detail, and labor not hereinafter specifically mentioned, which may be found necessary to complete or perfect any portion of installation in a substantial manner, and in compliance with the requirements stated, implied, or intended in these specifications shall be furnished without extra cost. This shall include all materials, devices, or methods peculiar to the machinery, equipment, apparatus, or systems furnished and installed as part of the plumbing work and shall include major components if so required.

E. The general arrangement of piping and equipment shall be as identified on the contract drawings. Carefully examine all contract drawings and be responsible for the proper fitting of materials and equipment in each location as indicated. Inasmuch as the drawings are generally diagrammatic, due to their small scale, it is not possible to indicate all offsets, fittings, and accessories, as may be required in the final installation. Carefully investigate the site, structural, and finish conditions affecting their work and arrange such work, accordingly, providing such fittings and accessories as may be required to meet such conditions, at no additional cost to the Owner. The right to make any reasonable change in location of apparatus, equipment, outlets, or routing of piping, up to the time of roughing-in, is reserved by the Design Professional without involving any additional expense to the Owner.

F. Should a bidder find discrepancies in or omissions from the drawings or specifications they shall notify the Design Professional before submitting their bid proposal. The Design Professional shall then send written instructions, via Addendum, to all known bidders. Oral instructions shall not be binding to either the Design Professional or the Owner.

G. In the case of discrepancies or conflicts between the Drawings and Specifications, typically the Drawings will take precedence in the case of quantitative issues, while the Specifications will take precedence for qualitative issues; or as specified in other Divisions; however, when the scale and date of the Drawings are the same, or when a discrepancy exists within the Documents and specific written direction cannot be obtained from the Design Professional, Bidders shall include the most stringent requirements. Obtain written clarification from the Engineer prior to installation.

H. Any such items not brought to the attention of the Design Professional prior to submission of the bids shall be subject to the interpretation of the Design Professional. All such interpretations shall be accepted by the Contractor and shall be incorporated into the construction in a timely manner, at no additional cost to the contract.

I. These Specifications are arranged in accordance with the MasterFormat 2016, 35 Division format. The Specification is to be read as a whole. Items or work called for on one paragraph or Section, shall be applicable to the entire work, unless specifically indicated otherwise. Specific contract scopes shall be determined by the General Contractor or Construction Manager.

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1.3 DEFINITIONS:

A. The following are definitions of words found in the various Sections of Divisions 22 and on the associated Plumbing drawings:

1. "Concealed" shall indicate hidden from normal sight in furred spaces, shafts, ceiling spaces, walls, and partitions.
2. "Exposed" shall indicate work normally visible, including work in Mechanical or Electrical equipment rooms, tunnels, and similar spaces.
3. "Provide" (and tenses of "provide") – shall indicate "supply and install, complete in all respects, for a complete and fully functional installation."
4. "Install" (and tenses of "install") – shall indicate "secure in position, make all final connections complete, test, verify and certify for a complete and fully functional installation."
5. "Furnish" (and tenses of "furnish") – shall indicate "supply only, complete with all required accessories, mounting hardware, etc., for installation by others, or as spare "attic" stock for the Owner's future use."
6. "Engineer" shall indicate person, firm or Corporation representing the Owner, and identified as such in the Contract Documents. The terms "Engineer" and "Architect" may be used interchangeably throughout the documents.
7. "Authority Having Jurisdiction (AHJ)" shall indicate the organization, office, or individual responsible for enforcing the requirements of the applicable codes or standards in the location where the project is to be constructed.
8. "BAS" shall indicate Building Automation System, and which shall also refer to by equivalent to references to "ATC" – Automatic Temperature Controls, "BMS" – Building Management System or "FMS" – Facility Management System. Any and all of these terms and acronyms may be used interchangeably to refer to the same functional system, specified under Divisions 21 - 25.

1.4 LAWS, REGULATIONS AND CODES:

A. Perform all work in strict compliance with all laws, regulations, and/or codes applying, including all Federal, State, and local codes and any other authority having jurisdiction. Wherever drawings or specifications conflict with such regulations they shall be made to conform, and approval of the Design Professional obtained on such changes as may be involved.

1.5 QUALITY ASSURANCE:

A. Comply with the requirements of the following codes and/or standards:

1. ASHRAE
2. ANSI
3. ASME
4. ASSE
5. ASTM
6. UL
7. NEMA
8. AMCA

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9. NFPA
10. ARI
11. NEC
12. IBC 2015
13. IMC 2015
14. IECC 2018
15. IFGC 2015
16. IPC 2015
17. PDI

B. All packaged equipment shall be independently Third Party labeled as a system for its intended use by a Nationally Recognized Testing Laboratory (NRTL) in accordance with the OSHA Federal Regulations 29CFR1910.303 and .399, as well as NFPA Pamphlet #70 and National Electric Code (NEC), Article 90-7.

1.6 PERMITS, FEES, AND CERTIFICATES OF APPROVAL:

A. Unless stated otherwise in General Conditions or Division 01, obtain, and pay for all permits, fees, and licenses required, including those of utilities and Agencies. Provide copies to Design Professional in the quantity requested.

B. "Fees" shall include connection charges construction costs, and other such charges by utility companies or service providers. Ascertain such charges during bidding period and include bid price.

1.7 REQUEST FOR INFORMATION (RFI):

A. The contractor is responsible for submitting Requests for Information (RFI)s when discrepancies arise, logical discrepancies are found on the contract documents, or clarification is necessary. All RFIs must be clearly written and submitted with a suggested solution. All RFIs regarding changes to the intent indicated on plans must be accompanied by sketches, explanation, site pictures, and all other instruments necessary, to clearly convey the issue at hand and the suggested solution. The RFI process may only be utilized for legitimate purposes. RFIs may not be utilized to submit deviation or substitution requests, nor requesting confirmation of scope for items clearly defined on the contract documents, nor related to clarifications that should be resolved through the Contractor's coordination efforts. RFIs that do not comply will be summarily rejected and any delays caused as a result are the responsibility of the Contractor. In cases where the Contractor does not submit an RFI to clarify an issue and incorrectly proceeds, all work required to resolve such issues to be in compliance with the intent of the contract documents, as determined by the Engineer, shall be the Contractor's responsibility and at no additional cost to the project.

B. The contractors are required to carefully examine all architectural and structural drawings for the building as well as all of the drawings for electrical trades, IT/AV/Security Trades, mechanical trades, and fire protection trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit or equipment. Refer to the coordination drawing requirements. Proper judgment shall be exercised to secure best possible headroom, ceiling heights, door and window clearance, and space conditions throughout; to secure neat arrangement for piping,

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equipment, and conduit, and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.

1.8 RECORD DRAWINGS:

A. Throughout the construction keep an accurate, up-to-date record of all deviations of the work between that as shown on the drawings and that which is actually installed.

B. Obtain a complete set of prints of the Plumbing drawings and note changes thereon. The design professional will provide the CAD files or Revit model for the contractor's use. Make a complete record in a neat and accurate manner, of all changes and revisions to original design which exist in completed work. As-Built markups shall be updated on a daily basis.

C. Submit As-Built documents in electronic CAD file format. The project design files will be provided to the Contractor by the Design Professional following proper execution of the Document Release and Indemnity Form as provided by the Design Professional. The electronic files returned by the Contractor shall be fully compatible with the native AutoCAD (*.dwg file formatat). In addition, submit a complete set of drawings in PDF format.

D. Room names and numbers shall be brought up to date to reflect actual project room signage and designations, which may be different from room indications shown on the contract drawings.

E. [The cost of preparing these record drawings shall be borne by the Contractor. When all revisions showing the work as finally installed are made, the prints and CAD files shall be submitted for review and approval by the Design Professional.

F. Record drawings shall be delivered to Owner within 30 days of project Substantial Completion.

1.9 OPERATION AND MAINTENANCE MANUALS:

A. Provide for the Owner's Use one (1) hard copy printed version and one (1) electronic copy in PDF format of a facility Operation and Maintenance Manual.

1. Hard copy Manual shall be bound in an extra heavy duty three-ring loose-leaf binder with the following title lettered on the front "Record and Information Manual (insert name of project)". No sheets larger than 8-1/2" x 11" shall be used, except sheets that may be neatly folded to 8-1/2" x 11" and used as a pullout.
2. Electronic format Manual shall be provided as a single .PDF file, fully bookmarked and indexed, containing all Owner's Manual data and project drawings.

B. Provide the following information in each Manual:

1. Cuts of all equipment with manufacturer's technical specifications. Material shall be manufacturer's brochures, catalog cuts, parts lists, wiring diagrams, etc. Also include approved shop drawings.
2. Operation, Maintenance and Servicing Procedures. Include frequency of inspection, cleaning and adjusting and other attention as may be required in accordance with manufacturer's instructions.

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3. Copy of project Warranty.
4. Contact name, telephone number and email address for obtaining replacement parts and service for all equipment.
5. Copy of all individual equipment warranties.
6. Copies of all required Test Reports.
7. USB drive with all Special Systems drawings in both PDF and editable format.
8. Electronic copy of all Owners Instruction and Training Sessions.

C. Furnish qualified personnel to instruct the Owner's personnel in the maintenance and operation of all equipment and systems. Instructing personnel shall remain on the job continuously during working hours until such instruction is complete, but not less than 16 hours.

D. A video recording in digital format of the operator training session shall be made during this training period and the digital video submitted to the Owner with the Operation and Maintenance Manuals.

1.10 WARRANTY:

A. The material and workmanship of all parts of the plumbing installations specified herein and shown on the drawings shall be warranted unconditionally for a period of two (2) years from date of Project Completion against defects arising from faulty materials or workmanship. Either replacement or repairs shall be made promptly on any defective materials or workmanship without charge for materials, equipment, or labor during that period.

B. Manufacturer’s warranties on equipment provided under this contract shall be included in the operating and maintenance manuals.

C. See specification section regarding restrictions on Early Use of Plumbing Equipment.

1.11 CORRECTION OF WORK AFTER FINAL PAYMENT AND WARRANTY:

A. This article is supplementary to Warranty Provisions of Division 01 and General Conditions.

B. Final payment shall not relieve the Contractor of responsibility for correction of faulty equipment, materials, and workmanship and, unless otherwise specified, they shall remedy any defects due thereto and pay for damage to other work resulting therefrom, which shall appear within the warranty period specified above.

C. Include warranties by the respective equipment manufacturers which shall be subject to the terms and time limits defined under these Divisions of Specifications.

D. Warranties furnished by Sub-Contractor and/or equipment manufacturers shall be counter-signed by the related Prime Contractor for joint and/or individual responsibility for subject item.

E. Manufacturers' equipment guarantees or warranties extending beyond the warranty period described herein shall be transferred to the Owner along with the Contractor’s warranties.

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1.12 COMMISSIONING:

A. Commissioning: Division 22 Contractors and vendors shall be part of a total building and system commissioning effort as conducted by the Commissioning Agent. Each contractor shall provide a technician and tools required to assist and facilitate the commissioning agent, as outlined by the commissioning plan. Where applicable and required, the contractor shall secure and pay for a factory technician to be part of the startup, testing and commissioning team and efforts. Full scope of work and all related responsibilities will be defined in Commissioning documentation.

1. All equipment shall be commissioned, and the operation of that equipment shall be checked by the installing contractor. Specific systems shall be commissioned when more than one contractor is involved in the installation or there is multiple system interface and control involved with that piece of equipment.
2. The contractors shall check and verify all equipment nameplate data against the design parameters, prior to installation.
3. The contractors shall submit a Spare Parts List for all equipment in the Maintenance and Operations Manuals to include, but not limited to the following:

   a. Part Numbers.
   b. Part and Equipment Description.
   c. Quantity of Parts Required.
   d. Lubrication Requirements.
   e. Full Warranty Information.
   f. Complete Operation and Maintenance Manuals.

B. Provide factory trained technician after successful startup, for on-site support. Allow for five (5) days on-site for this. These days may not be consecutive.

C. Provide six (6) additional site visits, after hours, after successful commissioning in the first year. For additional training and troubleshooting.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT:

A. All installed materials and equipment shall be new and the best of their kind and shall conform to the grade, quality and standards specified herein.

B. Unless otherwise specifically stated, all materials and equipment offered under these specifications shall be limited to products regularly produced and recommended by the manufacturer for the service intended. This material and equipment shall have capacities and ratings sufficient to amply meet the requirements of the project. The capacities and ratings shall be in accord with engineering data or other comprehensive literature made available to the public by the manufacturer and in effect at the time of opening of bids.

C. Equipment shall be installed in accordance with manufacturer's instructions for type and quality of each piece of equipment used. These instructions shall be obtained from the manufacturer and shall be considered part of these specifications. Type, capacity, and application of

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equipment shall be guaranteed suitable to operate satisfactorily. No experimental material or equipment shall be permitted.

2.2 WORK INCLUDED:

A. In addition to work described above under WORK DESCRIPTION, the work shall include but not necessarily be limited to the following:

1. Complete rainwater system terminating 5'-0" outside of building footprint.
2. Complete sanitary system terminating 5'-0" outside of building footprint.
3. All soil, waste and vent piping and connections to all plumbing fixtures and other equipment requiring soil, waste, and vent connections.
4. Sump pumps and controls.
5. All cold, hot, tempered and recirculating hot water piping and connections to all plumbing fixtures and other equipment requiring water connections. Domestic service. Domestic water pressure boosting system and controls.
6. Domestic water heaters and recirculating pump and controls.
7. All plumbing fixtures.
8. Natural gas piping system.
9. Insulation of all piping and other equipment as hereinafter specified.
10. All miscellaneous pipe, fittings, valves, hangers, anchors, sleeves, plates, flashings, and appurtenances necessary for a complete installation, leaving same ready for service. Unless stated otherwise all control wiring from electrical disconnect to valves, controls, and equipment, requiring same.
11. Disinfection of domestic water system.
12. All excavation and backfilling required.
13. Pipe and valve marking and tags. Painting as noted herein.
14. All testing and adjusting of all systems.
15. Instruction and equipment manuals.
16. Instruction of Owner's representatives.

2.3 EXCAVATION AND BACKFILL:

A. Perform all excavating and backfill necessary for work under this Contract. It is assumed that all excavation under this Contract will be soil excavation. In the event that rock is encountered, the Contractor shall be compensated for rock excavation in accordance with the unit prices or soil and rock excavation. Bidder shall state in their proposal, the unit prices for soil and rock excavation and the unit prices for soil excavation to be omitted. Rock excavation shall consist of solid rock or boulders over two cubic yards in volume or other material which can only be removed by line drilling or chipping by power equipment; blasting will not be permitted. In event rock is encountered notify the Design Professional of its existence in the areas not to be excavated and accurate measurements of the extent of the rock actually removed shall be made and submitted to the Design Professional.

B. Perform all excavating and backfill necessary under this contract. All excavation shall be unclassified, and includes the excavation and removal of all soil, shale, rock boulders, existing foundations, fill and every kind of sub-surface condition encountered in the contract area. No extra or additional compensation for excavation will be paid under this Contract.

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C. To protect persons from injury, and to avoid property damage, adequate barricade, construction signs, torches, lanterns, and guards shall be placed and maintained during the progress of the construction work and unit it is safe for traffic use. Rules and regulations of local authorities respecting safety provisions shall be observed.

D. The excavation may be accomplished by machine to within 2 inches of the sub-grade elevation. The excavation shall be completed by hand to neat lines.

E. Trenches shall be instrument graded using batter board and flow line and of sufficient width to provide a free working space of not less than 24 in. width and not greater than 12 in. on each side of the pipe barrel, whichever is greater. Trenches shall also be wide enough to thoroughly ram the backfilling around the pipe and to secure a firm bed.

F. In earth excavation, the trench shall be carried to the invert of the pipe. Where rock excavation is encountered, the trench shall be carried to a point 6 in. below the construction. No construction shall be bedded directly upon rock but shall be cushioned by a 6 in. layer of selected crushed stone or gravel.

G. Where material is removed below the grade of the bottom of a structure it shall be replaced with concrete of the same quality as the concrete in the structure. Where material is removed below the grade of a pipe trench it shall be replaced with a lean concrete mix. Make no excavation to depth below a line of slope one ft. rise on 2 ft. length from such excavation to bottom of footing on other construction.

H. Any piping that is run in unstable ground shall be supported on 5'-0" centers with concrete or brick piers. These piers shall be not less than 12 inches square and must reset on solid ground. Brick piers shall be laid in cement mortar.

I. Maintain banks at all times by means of shoring and bracing to avoid cave-in and make good any damage done to property or work of others due to failure to properly shore any excavation. Shoring done shall be removed after installation and test of lines have been approved. Material for shoring shall be placed in accordance with the regulations of the Department of Labor and Industry.

J. All excavations shall be left open until inspected and approved by the Design Professional. After the work has been installed, tested, inspected, the excavation shall be backfilled with the best carefully selected materials free from stones, large pebbles, hard lumps on frozen earth. Trenches shall not be backfilled until the work has been inspected and approved by the Design Professional. All backfill shall be made in 8 in. layers. The first 2 layers shall be fine earth, hand tamped. The remainder of the fill over new construction to the surface shall be ordinary approved excavated material placed in 8 in. layers and thoroughly compacted to not less than 90% of maximum Modified Density as determined by ASTM D 1557-70. No water soaking will be permitted. All excess materials shall be disposed of as directed. Seeding shall be by the General Contractor.

K. Where excavation is required under existing walkways and roadways, surface shall be restored with new materials equivalent to the material originally used. Whole cement pavement blocks shall be removed and replaced; removal and repair of partial blocks is not permitted.

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2.4 PUMPING:

A. Provide pumping equipment to pump all water to prevent it from collecting in trenches, basement areas, and any other excavations necessary to carry out contract requirements. Prepare run-off trenches as required to pump water into and use surplus earth to form dam at top of excavation to run back surface water.

2.5 CHASES AND OPENINGS:

A. Provide information to the appropriate trades regarding size and location of all openings and chases as required for the installation of this Plumbing Work.

B. Patching and repair of finishes will be by the General Contractor.

C. Provide sleeves for pipes passing through poured concrete decks, footings, walls, etc. Cut all openings for piping passing through precast concrete or existing concrete or masonry. Such holes shall be cut with core drill or similar equipment. They shall not be cut with hammer and chisel, or with any power tool depending on impact for its cutting power.

2.6 CUTTING AND PATCHING:

A. All cutting and patching for installation of plumbing work will be done by others.

B. Provide all information required for such openings to the appropriate trade in a timely manner.

C. Provide all cutting and patching required for work performed under this Contract. No holes may be cut or drilled in structural members without prior approval of Owner's Representative. Cutting shall be done by mechanics skilled in their respective trades.

D. No cutting that may impair the strength of the building construction shall be done. No holes may be drilled in, or attachments welded to the beams or other structural members without prior approval from the Owner's Representative. All work shall be done by mechanics skilled in their trade.

E. All patching shall be done in a manner to match appearances and quality of existing surfaces.

F. Provide sleeves for pipes passing through poured concrete decks, footings, walls, etc. Cut all openings for piping passing through precast concrete or existing concrete masonry. Such holes shall be cut with core drill or similar equipment. They shall not be cut with hammer or chisel, or with any power tool depending on impact for its cutting power.

G. For holes and openings in pre-cast concrete, 2-1/2" round and above, or 2-1/2" and above on longest side, prepare a drawing for the Design Professional's approval for same to be pre-cast in the factory; for holes and openings smaller than above, prepare a drawing for the Design Professional's approval for same to be cut, cored, or drilled in the field by the plumbing trade.

H. Each contractor shall be responsible for sealing under-floor penetrations related to their trade. The testing and balancing contractor will measure the amount of air leakage and approximate location of leaks. Each contractor shall reseal and repair any leaks associated with their trade, occurring at locations determined during testing and balancing.

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2.7 CONCRETE:

A. Provide concrete work and housekeeping pads required for work performed under this Contract for all floor mounted plumbing equipment.

B. Concrete shall have a compressive strength of 3,000 psi minimum at twenty-eight days. Placing of reinforcing steel and concrete shall be done according to the recommendations of the American Concrete Institute and Concrete Reinforcing Steel Institute, and all materials shall conform to American Society for Testing Materials Specifications, applicable to this work. Equipment pads shall be properly dowelled in with floor construction and shall have sloped bevels on all horizontal and vertical edges.

C. Form work shall be of sufficient strength to maintain desired shape during pouring of concrete and tight enough to prevent leakage of the grout through joints.

D. Submit shop drawings for approval showing dimensions, reinforcing, and dowelling for all floor mounted plumbing equipment.

E. Provide at the time of pouring concrete, all necessary anchor bolts. Anchor bolts shall be the hook type, of proper size and length to suit the equipment. Anchor bolts shall be set in pipe sleeves of approximately twice the bolt diameter and one half the embedded length of the bolt. Assume full responsibility for proper emplacement of the bolts.

F. Drop-in wedge anchor bolts or self-drilling anchors may be used in place of hook bolts. Minimum embedment in concrete of wedge anchor bolts shall be in accordance with manufacturer's instructions. Wedge anchor bolts shall be manufacturer by Phillips Drill Co. or USM Corp. Self-drilling anchors shall be manufactured by Phillips Drill Co.

G. After equipment is set in place and bolted down, any space between equipment base and floor slab or foundation shall be completely filled with non-shrink grout equal to Master Builders Co., Ltd. Embeco 153 grout.

2.8 STARTERS AND PILOT DEVICES (OR MOTOR CONTROLS):

A. Combination magnetic motor starters shall be full voltage non-reversing with an adjustable instantaneous-trip circuit breaker or fused or unfused safety switch withstand rating 65,000 ampere rms symmetrical minimum. Motor starters shall have UL508 symmetrical RMS ampere interrupting rating in accordance with equipment specifications or as required by Electrical Coordination Study specified in Electrical General Requirements: Division 26. Starters and protective devices shall be of sizes recommended by manufacturer for the motor to be controlled, but minimum size shall be NEMA size 1.

B. Combination magnetic motor starters shall be full voltage non-reversing with a fused safety switch. Starters and protective devices shall be of sizes recommended by manufacturer for the motor to be controlled, but minimum size shall be NEMA size 1.

C. Starters, which are not combination shall be similar, but without circuit breaker or switch.

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D. For description of starters, refer to Division 22 and 26 Specifications. This Schedule describes which starters are combination, and if so, what type of device they require. This Schedule also indicates the type of pilot device(s), indicators, auxiliary relays, etc. to be supplied. In the absence of any such instruction, furnish non-combination starter with "hand-off-auto" selector switch, green "run" pilot light, and two (2) auxiliary contacts.

E. Where starters or other devices are to be mounted outdoors, such as on a cooling tower, enclosures shall be NEMA Type 4. All other enclosures, unless otherwise noted, shall be NEMA Type 1.

F. All starter control circuits shall be 120V (or 24 VAC if required to interface with BMS/BAS equipment). Voltage shall be derived from starter line voltage via fused control transformer. Control transformers shall have sufficient capacity to properly operate any auxiliary equipment, such as dampers, electro-pneumatic switches, or other devices. Provide transformers larger than manufacturer's standard size, as required by these conditions. Provide sufficient auxiliary contacts to properly interface with ATC equipment, or other devices interlocked with the motor in question.

G. Manual starters shall be toggle type, in surface or flush enclosure as required, and with pilot light. Provide overload heaters unless the motor to be controlled is thermally protected.

H. Unless otherwise noted, overload heaters shall be melting-alloy non-automatic-reset type. Overload heaters shall not be selected based on average published motor currents but shall be selected based on the actual nameplate current of motors and service factor as installed.

I. Push buttons, selector switches, pilot lights and similar pilot devices shall be NEMA 1 or NEMA 4, as noted in D, above. Pilot lights shall be neon or transformer type. Provide manufacturer's standard engraved nameplates which display the control function of the device (or for pilot lights, the action indicated).

J. Electrical Contractor shall install all individually mounted starters. Electrical Contractor shall provide line and load side power wiring. Coordinate with Mechanical Contractor for all BMS/BAS control interface/interlocks. Mechanical Contractor shall turn over all starters to the Electrical Contractor for installation. This Contractor shall furnish, install, and wire all other (pilot) devices, and provide cell control wiring for starters. See Division 23 “Sequence of Operations” Specification for additional details.

K. All starters and controls shall be Square D, General Electric, Allen Bradley, Cutler-Hammer or Siemens.

2.9 ELECTRICAL WORK AND MOTORS:

A. All electrical work shall be done in strict accordance with the requirements of the National Electrical Code and the Electrical Specifications. All electrically operated equipment shall bear an Underwriter's Laboratories label where labeling service is available for that type of equipment.

B. All motor frames shall be grounded. Electric power, control and grounding connections shall be factory wired to an outlet box or terminal strip enclosure on the apparatus for easy connection by the Electrical Contractor.

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C. All motors shall be designed and constructed in accordance with the latest standards of the IEEE and NEMA and shall meet UL requirements. Motors shall run quietly under all operating conditions.

D. See Division 26 Specification for additional details.

2.10 WIRING FOR CONTROL SYSTEMS:

A. This Article applies to wiring used for plumbing systems and similar types of control systems associated with work of Division 22.

B. All wiring for control systems shall comply with Article 725 of the National Electrical Code, (NEC) or with Articles 760, 800, or 820 for control systems integrated into systems covered by those Articles.

1. Particular attention shall be given to the requirements of the NEC for testing and labeling cables for use in plenums, risers, and other air-handling spaces.

C. All wiring for control systems shall be of a type recommended by the system manufacturer and be installed in accordance with systems manufacturer's instructions.

D. Cables must be in raceways when run through inaccessible ceilings, walls, or chases. Comply with Division 26 Specifications, for types of raceways required and their installation requirements. Cables run on surfaces within 8' of finished floor must be in raceways where exposed to physical damage. Cables in mechanical spaces must be in raceways.

1. Where cables enter or leave raceways, provide insulated bushing or protective grommet.

E. Cables may be run without raceways above accessible ceilings; in hollow stud partitions; and where properly supported in unfinished spaces without ceilings.

F. Cables run without raceways in concealed locations or unfinished spaces shall be supported by bridle rings or similar hangers attached to the building structure at maximum 5'-0" centers. Hangers and/or cables shall not be supported from pipes, ducts, or similar equipment. Cables shall not be supported by lying on or across framing members or structural elements.

G. Where cable is run exposed in finished areas, it shall be supported by bridle rings and beam clamps at maximum 4' intervals. All cables running along a given beam, joist, or truss shall be bundled together and run parallel to each other. Bundle shall be tied together at 2' intervals with T&B “Ty-raps” or equal nylon cable tie. Ty-raps shall be exposed one foot on either side of bridle ring supports. Cables shall be pulled as tight as possible and run as straight as possible.

1. Where cables bend, bends shall be 90 degrees; parallel cables shall have symmetrical turns. Bending radius shall be no smaller than manufacturer’s specification for level of cable involved. Individual cables shall be supported with metal straps listed for the purpose. All cables shall be run parallel with or perpendicular to building lines, plumb and true. Cable loops connecting to boxes or fittings shall be as short and neat as possible.

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2. See details on Electrical Drawings for general information regarding cable support. All cables run on steel structure will be painted to match steel; cable supports, ties, etc., must be installed prior to painting.
3. Cables shall be maintained at a spacing of 6" from 120 V and higher voltage AC conductors, unless installed in a grounded metallic raceway.

H. Wiring with or without raceways shall be run continuously between terminal boxes and outlets. All splices shall be made in NEMA 1 boxes with terminal strips or other acceptable connectors and permanent labels to identify each wire and cable, both entering and leaving the box.

I. A separation of not less than 6" shall be maintained to heated pipelines.

J. Cable run above hung ceilings used for environmental air shall be specifically listed and labeled for the use or shall be installed in a raceway.

K. Wiring run without raceways through rated walls, floors and partitions shall be run in sleeves. All such sleeves shall be packed with fire-rated material.

L. Wiring for different systems shall be grouped and run separately from other systems and shall be identified as to the system it serves.

M. Where equipment to be provided is controlled with line voltage devices (thermostats, speed controllers, timers, etc.), these devices shall be furnished to the electrical contractor for mounting and wiring of same.

N. All electrical wiring in connection with the BAS shown on the electrical drawings shall be installed by the Electrical Contractor. Any wiring not shown but required for proper operation of the automatic temperature control system, shall be performed by the Control Contractor and shall be in complete accordance with National Electrical Code, latest edition, and the Electrical Contract Specifications.

2.11 FLASHING AND ROOFING WORK:

A. The Contractor shall perform all cutting, patching, and sealing of existing roofs as required for the installation of all work under this Contract.

B. The contractor bears complete responsibility for maintaining and obtaining the watertight integrity of the affected areas of the roofs both during and after the completion of construction.

C. The Contractor shall provide all base flashings, counter flashings, and hot applied roofing materials necessary to properly flash and seal the roofs as required and to prevent any water or moisture leakage whatsoever from occurring as a result of this work.

D. Unless noted otherwise, all flashings shall be minimum 24-gauge galvanized steel. Base flashings shall have minimum 4" roof flanges on all sides. Flanges of all base flashings shall be secured and stripped into existing roofing in accordance with the best practices and methods of the roofing trade for a watertight installation.

E. All joints and seams of all flashings shall be continuously soldered.

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F. After installation, all exposed metal surfaces of base flashings shall be given two (2) applications of roofing coating.

G. All roofing work shall be performed by first class mechanics experienced in the roofing trade.

H. The contractor must exercise extreme care so as not to damage existing roofs while working thereon and they shall provide protection planking and plywood as required to achieve this result. Any damage to the existing roofs and their watertight integrity caused as a result of work being performed under this Contract shall be properly repaired by the Contractor to the satisfaction of and at no cost to the Owner.

I. Refer to drawings for additional flashing details and roofing work required.

2.12 SUBSTITUTIONS:

A. Equipment may be shown or specified in several ways:

1. Several manufacturers and model numbers listed; or one manufacturer and model number, followed by "equals by (mfr A), (mfr B), (mfr C)," or words of similar respect.

   a. If one of the manufacturers is listed on the drawings, that manufacturer shall be considered the basis of design. If none is so listed, the first manufacturer named in the Specification shall be considered the basis of design.
   b. Where manufacturer's or supplier's name, style and catalog numbers are mentioned in the description of material and equipment in the specifications or on the drawings, it is to be understood that they are for the purpose of setting a standard.
   c. If Contractor elects to furnish equipment other than the basis of design, they shall verify capacities, physical size, weight, electrical requirements, methods of connection to other parts of the system, and all other relevant data. Contractor shall be responsible for informing the Design Professional of all changes required to other equipment, spaces, structure, or systems in order to install the substituted equipment. They shall furnish all required shop drawings or sketches required for Design Professional to evaluate the required changes and shall be responsible for all costs associated with such changes, including costs of design or engineering, if such are necessary, and costs of other trades.
   d. Accompany the request for substitution review with a table of comparisons listing pertinent features of both the specified and proposed materials including performance data, weight, material of construction, overall length, width, height dimensions, space required for replacement or maintenance access, motor type, horsepower, voltage, phase service factor, and noise levels. Review of proposed substitution will not be made until receipt of the complete comparison tabulation.

2. Where manufacturer's or supplier's names are listed in conjunction with the manufacturer or supplier that is basis of design, they are given to approve the firm name only. Equipment or material submitted by such firms must meet the detailed technical specifications written for the respective item. Contractor shall be responsible for verifying capacities, physical sizes, weights, electrical requirements, and methods of connection to other parts of the system, etc. Contractor shall furnish all required shop drawings for equipment, and for its connection and installation.

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B. If any substituted items are submitted after contracts have been awarded, and there is any question of equality of such items, samples may be required to be submitted both for the item specified and that to be substituted, or further proof of equality may be required to the entire satisfaction of the Design Professional. In no case shall additional remuneration be allowed because of the rejection of a substitute.

C. When the equipment is relocated to a place other than that shown on the drawings, or when equipment other than that specified is used, the Contractor shall pay the extra cost of required revisions such as structural steel, concrete, electrical, piping, etc.

D. The Design Professional's costs to evaluate substitutions and to revise Drawings and Specifications because of substitutions will be paid by the Contractor.

2.13 SHOP DRAWINGS:

A. Refer also to Division 01.

B. Furnish shop drawings, catalog cuts, performance data and other required data to the Design Professional for approval for all material and equipment specified hereinafter. Sufficient data shall be submitted to show compliance with the requirements of the plans and specifications. All shop drawings submitted shall be first checked and corrected before submitting for approval. Approval for shop drawings by the Design Professional will not relieve the Contractor from responsibility for errors or omissions therein. All such errors or omissions must be made good by the Contractor irrespective of any approval by the Design Professional.

C. It is the responsibility of the manufacturer’s representative and the installing contractor to thoroughly review all shop drawing equipment submittals and state in writing that the products meet or exceed the design specifications and design intent as indicated on the contract documents, prior to submitting them for review by the engineer.

D. Types of submittals:

1. Action Submittals: To be provided from the contractor to the engineer of record for review and approval.
2. Informational Submittals: To be provided by the contractor to the architect/owner for record only. They are not subject to review and approval by engineer of record.
3. Close-Out Submittals: To be provided from the contractor to the owner for record only at project close-out. They are not subject to review and approval by the engineer of record.

E. The General Contractor or Construction Manager shall review and stamp all shop drawings noting their review process has taken place and that the shop drawings are in compliance with the design documents, prior to submitting for review by the engineer. Any shop drawings found to not be in compliance shall be returned to the contractor stating such, with a copy of the statement (only) forwarded to the engineer.

F. On submissions beyond the initial one, clearly identify all of the changes made from the initial submittal those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.

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G. The Engineer will review three submissions (one original submission and up to two revised submissions) on any single component requested for review. If the contractor and/or vendor fail to comply with the drawings, specifications, and/or review comments and additional submissions are required, the cost for review and processing of those submissions will be borne by the contractor.

H. The design documents are based and coordinated on the scheduled manufacturers. Any substitutions of products or materials (from those approved and listed in the specifications) must be thoroughly coordinated by the submitting contractor. This includes but is not limited to power, space, structural, control and performance requirements.

I. Shop drawings required shall include, but not necessarily be limited to, the following:

1. Shop drawings, cuts and catalogue information showing appearance, dimensions, performance, weight, etc., of all equipment, appurtenances, etc.
2. Schedules of all materials showing type and manufacturer.
3. Wiring diagrams and schematics for equipment.
4. All special equipment and systems.
5. Any special constructions.
6. Other shop drawings as may be requested.

J. Digital files of mechanical work will not be provided for the purpose of shop drawing preparation. Digital files of architectural plans, elevations, sections, etc. may be available for background purposes; it is the responsibility of the Contractor to confirm availability prior to bid.

K. Shop drawings shall be submitted in a timely manner, taking due account of time requirements for processing, correcting, and distributing the shop drawings to all persons or trades requiring the information, as well as time required for manufacture of the equipment. Design Professional will not be responsible for construction delays resulting from late submission of shop drawings, nor for delays caused by the need to correct and resubmit shop drawings which were not correct, which involved substituted equipment, or otherwise required review, correction, and resubmission.

L. If Contractor elects to proceed to install equipment for which approved Shop Drawings have not been received, they do so at their own risk; Design Professional is not obligated to accept such equipment or work, nor will Design Professional be liable for claimed costs or delays required by correction of such work.

M. Identify each submittal, including shop drawings, catalog data, test reports, operation and maintenance manuals, and record documents, with the following data:

1. Buyer’s name.
2. Project name.
3. Project location.
4. Buyer’s purchase order number.
5. Reference specification order number.
6. Name of contractor making the submittal.
7. Revision level of submittal and date of revision.

N. For equipment, provide the following information on each submittal:

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1. Equipment tag number.
2. Equipment description.
3. Equipment manufacturer's contact information.
4. Local equipment representative's contact information.

O. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristic, finishes for materials, and installation and startup instructions for each type of product indicated.

1. Each control device labeled with setting or adjustable range of control.

P. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Schematic flow diagrams showing all controlled equipment and control devices.
2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
3. Details of control panel faces, including controls, instruments, and labeling.
4. Written description of sequence of operation.
5. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
6. Listing of connected data points, including connected control unit and input device.
7. System graphics indicating monitored systems, data point addresses, and operator notations.
8. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.

Q. Shop Drawings shall be submitted and shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Shop drawings shall also contain complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, calculations, and any other details required to demonstrate that the system will function properly. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work.

R. Shop Drawings shall be approved before any equipment is installed. Therefore, shop drawings must be submitted in time for review so that all installations can be completed per the project completion schedule. Ten (10) working days shall be allowed for submittals to be reviewed by the Engineer.

S. All drawings shall be reviewed after the final system checkout and updated or corrected to provide "as-built" drawings to show exact installation. All shop drawings will be acknowledged in writing before installation is started and again after the final checkout of the system. The system will not be considered complete until the "as-built" drawings have received their final approval. The Contractor shall deliver a complete set of "as-built" drawings.

T. On submissions beyond the initial one, clearly identify changes made from the initial submittal other than those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.

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Shop Drawing Review Comment Definitions

A> No Exception Taken:

The shop drawing or equipment submittal as submitted is approved without exception. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

B> Make Corrections Noted:

The shop drawing or equipment submittal as submitted is not completely correct but is approved as noted. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted can be released for fabrication and construction once the corrections have been made. The submittal must be corrected and resubmitted for record unless noted by "E: Resubmit". See "E: Resubmit definition below.

C> Submit Specified Item:

The shop drawing or equipment submittal as submitted is missing a component of the system that it represents or is not of the approved and specified manufacturers. Submit the missing or incorrect item. The materials, equipment or system submitted cannot be released for fabrication and construction.

D> No Further Submission Required:

The shop drawing or equipment submittal as submitted is approved as noted. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

E> Resubmit:

The shop drawing or equipment submittal as submitted is not approved. The shop drawing or equipment submittal needs significant corrections and does require another submission to verify that the comments and changes have been incorporated. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted cannot be released for fabrication and construction.

F> Rejected:

The shop drawing or equipment submitted is not as specified or a non-approved manufacturer or product and rejected.

G> Resubmit for Record Only:

Make the corrections noted on the shop drawing or submittal. The shop drawing or equipment submittal as submitted is approved with minor exception. Changes or corrections are required. The materials, equipment or system submitted can be released for fabrication and construction.

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PART 3 - EXECUTION

3.1 VISIT TO SITE:

A. Before submitting bid, visit the site of the work and be thoroughly familiarized with the conditions affecting the work. No extra payment will be allowed on account of extra work made necessary by failure to do so.

3.2 WORKMANSHIP:

A. All work shall be installed in a first class, neat and workmanlike manner by mechanics skilled in the trade involved. All details of the installation shall be mechanically correct. Should the Design Professional direct removal, change, or installation of any equipments or systems not installed in a neat and workmanlike manner, such changes shall be made by the Plumbing Contractor at no expense to the Owner.

B. Equipment shall be installed in strict accordance with manufacturer's instructions for type and capacity of each piece of equipment used. The Contractor shall obtain these instructions from the manufacturer and these instructions shall be considered part of these Specifications.

C. Drawings are generally indicative of the work to be installed, but do not indicate all bends, fittings, and specialties which may be required, or the exact locations of all piping and equipment. Contractor shall investigate structure and finish conditions affecting their work and arrange their work; accordingly, furnishing such fittings as may be required to meet such conditions. Contractor is responsible for exercising proper judgment to arrange their work and materials so as to avoid interference with other trades.

1. Riser diagrams and schematics generally indicate equipment to be used in various systems involved. This information may or may not be duplicated on the plans, but equipment shown on either plans or riser diagrams and schematics shall be provided as if shown on both.
2. All grades, elevations, dimensions, and clearances of equipment shown on drawings are approximate and shall be verified at site.
3. Where work or equipment is referred to in singular terms, such reference shall be deemed to apply to as many items of work or equipment as required to complete entire installation.

3.3 LINES AND GRADES:

A. Lay out work and establish heights and grades for work in strict accordance with the intent expressed by the drawings and all the physical conditions at the building and be responsible for the accuracy of same.

3.4 FIELD MEASUREMENTS:

A. Before ordering any material or doing any work, verify all measurements at the building and site and be responsible for the correctness of same. No extra compensation will be allowed on

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account of differences between actual dimensions and measurements and those indicated on the drawings. Any difference which may be found shall be submitted to the Design Professional for consideration before proceeding any further with the work.

3.5 DELIVERY OF EQUIPMENT:

A. Be responsible for delivery of equipment, unload, and store in a manner not to interfere with the operation of other trades. Additional expense incurred because of equipment or material delivery delays shall be assumed by the responsible Contractor.

3.6 RESTRICTIONS ON EARLY USE OF PLUMBING EQUIPMENT:

A. The plumbing equipment provided under this contract shall not be operated prior to the completion of construction of the building for reasons other than testing and balancing of the systems, unless specifically directed and/or approved by the Owner. This specifically prohibits the use of permanent equipment for the purposes of ventilating, heating, and dehumidifying the building while under construction.

B. Should a contractor choose to use any component of the permanent plumbing system for purposes other than stated above, they shall assume full responsibility for replacing or repairing any equipment damaged as a result of the use and pay all costs associated with the action required to make the equipment in "like new" conditions at the end of the project. This includes cleaning of ducts and coils, replacement of motors, extension of warranties, payment of design professional fees required to investigate and enforce this requirement, and the correction of any other detrimental conditions which is determined by the design professionals to be related to the early use of the equipment.

C. Should the early use of equipment result in manufacturer's warranty being void, the contractor shall assume the cost of furnishing an equivalent warranty to the owner.

D. Should pump motors be operated during construction, any motor determined by the owner or design professional to be exposed to airborne construction dust, such as generated by drywall sanding, shall be inspected by an independent 3rd party for damage. The costs of all required corrective actions shall be borne by the contractor responsible for the operation of the equipment.

3.7 PROTECTION OF WORK:

A. All work, equipment and materials shall be protected at all times.

B. All piping openings shall be closed with caps or plugs during installation. All equipment shall be tightly covered and protected against dirt, water, plaster, paint and other foreign material or mechanical injury during entire progress of installation. Make good all damage caused either directly or indirectly by workmen employed to fulfill requirements of the Plumbing Work.

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3.8 REMOVAL OF RUBBISH:

A. During the course of construction, periodically remove from the premises all rubbish resulting from work of this trade so as to prevent its accumulation. At the completion of the work contemplated under these Specifications remove from the building and site all rubbish and accumulated materials of whatever nature not caused by the other trades and leave work, and equipment free of all foreign matter including plaster, cement, and paint and leave in a clean, orderly, acceptable, and usable condition.

3.9 COORDINATION WITH OTHER TRADES:

A. Work in conjunction with each of the other trades to facilitate proper and intelligent execution of work with minimum interference.

B. Carefully examine all architectural and structural drawings for the building and drawings for electrical trade and other mechanical trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit, or equipment. Proper judgment shall be exercised to secure best possible headroom, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment, and conduit: and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.

C. Contractor shall prepare preliminary sheet-metal shop drawings suitable for use in coordinating their work with the work of other trades. The Mechanical Contractor shall prepare and furnish CAD or 3D BIM files of drawings at 3/8" = 1'-0" scale illustrating the coordination with all trades. Drawing shall indicate equipment access requirements, piping, ductwork, and conduit in relation to all structural elements of the construction, including floor elevations; steel locations, size, and elevations; partitions locations; door locations and direction of swing; and all other information required to assure coordination of the electrical, sheet-metal and piping trades and fire protection in relation to the Architectural function of the project. Coordination meetings shall be held under the supervision of the Owner's Construction Manager and General Contractor. Each trade shall have proper representation at all coordination meetings for the purpose of detailing, on a print of the coordinated drawing mentioned above, the exact location and routing of their work. After the conclusion of the coordination at the working meetings, each trade shall sign the coordinated print, copies of which shall be distributed by the GC to all contractors and parties concerned including the Owner. A print of each final coordination CAD drawing with the participants contractor’s “signoff” signatures appended shall be submitted to the design professional for record.

D. If contractor installs work so as to cause interference with work of other trades, they shall make necessary changes in work to correct the condition without extra charge.

E. Dimensional layout plans of equipment rooms shall be made showing all bases, pads and inertia blocks required for mechanical equipment. Include dimensions of bases, bolt layouts, details, etc.

F. Contractor shall furnish all necessary templates, patterns, etc. for installing work and for purpose of making adjoining work conform, furnish setting plans and shop details to other trades as required.

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G. The drawings and model development for the project is based on specific equipment and materials, as the Basis of Design. This equipment and materials have been developed, designed, and graphically represented within the model, such that the quality, size, shape, location, and orientation can be determined and measured. Non-graphic information may also be attached to the model element. The model does not fully resolve all minor spatial conflicts. The Contractor may utilize the model in developing his/her construction level drawings as well as shop drawings and submittals. The contractor shall update the spatial requirements of the equipment and materials, based on his/her final approved vendor selections and interdisciplinary coordination.

3.10 COORDINATION OF CONTROL EQUIPMENT:

A. The Plumbing Contractor shall furnish all starters, push buttons for local or remote control, controllers, pressure switches, aquastats, thermostats, float switches or similar items together with all appurtenances and accessories required to operate the equipment furnished under these specifications and necessary to perform the operating functions as specified, shown on the drawings, or otherwise required.

B. Refer to Schedule of Control Equipment on Drawings for type of controls required. The Electrical Contractor will mount and provide power-wiring for all starters and will furnish and install all other safety switches or other line-disconnecting or protective devices. Where the starter and/or safety switch is an integral part of the equipment assembly, the assembly shall be furnished with the wiring complete between starter, controller and motor and the Electrical Contractor will make power connections only.

C. All control wiring to automatic-operated switches, pressure switches, aquastats or other devices which actuate the starter or other items associated with the systems shall be furnished, installed, and wired by the Plumbing Contractor. The Electrical Contractor will supply 120V electric power to the control panels for these special systems to the extent shown on Electrical Drawings. All other wiring (including additional power circuit if required) shall be the responsibility of the Plumbing Contractor.

D. The Plumbing Contractor shall carefully check the current characteristics available to each location before ordering motors.

E. If procurement requirements necessitate a change in voltage, phase, horsepower or other characteristics of any motor, the Plumbing Contractor shall obtain approval of such change from the Design Professional and shall be responsible for necessary arrangements for notifying the Electrical Contractor, and shall pay the costs, if any, required by the change, including Engineering costs.

F. All electrical equipment furnished and installed under this contract shall be furnished with full complement of control equipment, control wiring, conduit, and all other items necessary for satisfactory operation.

G. The Electrical Contractor will complete all electrical power connections, through the disconnect and/or thermal cutouts, starter, and motor terminals. They will be responsible for final power connections.

H. The Electrical Contractor will be responsible for proper rotation of three phase equipment.

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I. All electrical work, equipment and material furnished under this Section shall be furnished and installed in accordance with Division 26 Electrical Specifications.

J. All panels, relays, terminal boxes, contactors, circuit breakers, safety switches, motor starters and similar items shall be identified by Name, Function and/or Control. Nameplates shall be at least 1" x 3" with characters not less than ¼". They shall be made of two laminated black plastic sheets bonded with a middle sheet of white plastic and characters engraved in one black sheet to the depth of the white plastic. A typewritten list of Nameplates shall be submitted to the Design Professional for approval before ordering same.

3.11 EXPANSION OF PIPING:

A. All piping connections shall be made so as to allow for perfect freedom of movement of piping during expansion and contraction, without springing or creating air pockets which will impair the flow of the water through the system. Install expansion loops as shown on the drawing or as required. Expansion loops shall be made with swing joints, bends, or long offsets as necessary. Provide expansion guides.

3.12 ANCHORS AND GUIDES:

A. Anchors shall be provided where shown and/or required for the proper control of stress in piping due to expansion.

3.13 ACCESS:

A. All equipment and valves requiring maintenance or adjustment must be accessible. Items located above ceilings shall be located above accessible portions of the ceiling or above access panels provided by this Contractor. Manufactured items with internal components requiring access (whether integral with the enclosure or not) shall be provided with access panels.

3.14 CONCRETE HOUSEKEEPING PADS:

A. Refer also to “Concrete” article in Part Two of this specification section.

B. Concrete housekeeping pads shall be provided for all floor mounted plumbing equipment. Where pads are shown on the drawings, they are representative only and do not necessarily indicate all locations where pads are required.

C. Pads shall be not less than 6" above the floor and shall extend not less than 6" beyond the equipment base in all directions, unless otherwise noted on the drawings.

3.15 FIRE STOPPING:

A. All penetrations through fire-resistance-rated floor, fire resistance rated, floor/ceiling assemblies and roof construction and through fire-resistance-rated walls and partitions shall be fire stopped.

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B. Penetrations to be fire stopped include both empty openings and those containing cables, pipes, ducts, conduits, and any other items.

C. Fire rating of sealed penetrations shall meet or exceed the rating of the assembly being penetrated.

D. Materials shall be installed in accordance with manufacturer's recommendations and their UL listing.

3.16 PREPARATION FOR TESTING AND BALANCING:

A. Review Contract Documents and submittals to verify that piping, instruments, thermowells, valves, measurement and control devices, and access openings have been provided in correct quantity and at correct locations to permit testing and balancing of domestic hot water systems under various operating conditions.

B. Inform TAB Agency regarding major deviations from Contract Documents made to systems during construction and furnish one (1) complete set of Record Drawings, showing presence and location of balancing elements, and instrument ports, prior to start of TAB work.

C. Provide indicated Work and submit certification that each operation indicated is complete and in accordance with Contract Documents. Accomplish this Work before TAB work can start. Within 30 days of notification by Owner of award of Testing and Balancing Contract, submit schedule to complete following work:

1. Complete physical installation.
2. Pressure test systems as required.
3. Clean, flush, and fill domestic hot water systems as required. Provide temporary start-up strainers and replace with clean strainers after system cleaning as indicated.
4. Test and operate prime movers, at full design load to verify adequate power, proper rotation, completed controls, operational auxiliaries, and complete overall installation.
5. Properly evacuate air from liquid systems. Verify that expansion tanks are filled and in proper working order.
6. Verify that control valves are in proper working order and location, that they are marked and installed with correct "NORMAL" positions as required, and that hand valves and balancing valves are positioned for full flow through equipment.

D. For each item of plumbing equipment, submit typed Data Register in non-yellowing, clear plastic binder, and securely attach it to associated equipment. Show operating temperature, pressure, flow rate, amperage, voltage, phase, frequency (Hz), rpm and brake horsepower {input power (kW)}, as appropriate.

E. Deliver to TAB Agency, for use until TAB work is complete, flow-indicating devices intended for use with permanently installed primary flow measuring devices. Calibrate permanently installed flow measuring devices and associated display instruments, thermometers, sensors, and pressure gauges. Deliver documentation to TAB Agency to verify calibrations.

F. Submit schedule stating when each system is ready for TAB work to begin. Separate schedule by area, and mechanical system. Submit schedule within 30 days of Contract Award. Update schedule at least two (2) months in advance of scheduled start of TAB work.

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G. Attend coordination meetings between TAB Agency, and Owner's Representative, conducted under guidance of Contractor. First meeting is approximately two (2) weeks before scheduled start of TAB work, as scheduled by Plumbing Contractor, and approved by Owner's Representative.

H. Provide labor, material, tools, and equipment to operate mechanical equipment and systems during TAB work, and for required adjustments, calibrations and repairs of control devices or their components. Provide these services on each working day and without undue delay, as required by TAB Agency. Protect and operate equipment and systems during TAB work.

I. When requested by TAB Agency, furnish services of personnel to accompany TAB Agency when TAB work is being performed.

J. Make modifications at no additional cost and to satisfaction of Owner's Representative to rectify discrepancies reported by TAB Agency indicating non-compliance with Contract Documents.

END OF SECTION 22 00 00

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SECTION 22 00 05

COORDINATION DRAWING REQUIREMENTS FOR PLUMBING

PART 1 – GENERAL

1.1 COORDINATION DRAWINGS

A. All mechanical, electrical, plumbing, fire protection, telecommunications, and ATC subcontractors will be required to use AutoCad (CAD) or 3D BIM format. Coordination drawings will be distributed via email and/or disk.

B. For 3D BIM projects, the CM/GC shall hold BIM coordination meetings with all trades to resolve conflicts and to coordinate the installation layouts. The BIM coordination meetings shall be at a frequency necessary to complete the overall coordination tasks and efforts.

C. The drawings and model developed for the project is based on specific equipment and materials, as the Basis of Design. This equipment and materials have been developed, designed and graphically represented within the model, such that the quantity, size, shape, location and orientation can be determined and measured by the contractor. Non-graphic information may also be attached to the model element. The model does not fully resolve all minor spatial conflicts. The Contractor may utilize the model in developing his/her construction level drawings as well as shop drawings and submittals. The contractor shall update the spatial requirements of the equipment and materials, based on his/her final approved vendor selections and interdisciplinary coordination.

1.2 ABOVE CEILING AND NO CEILING OVERHEAD INSTALLATION

A. The Mechanical Contractor shall furnish minimum 1/4" scale CAD electronic background drawings of the sheet-metal shop drawings, for incorporation of plumbing and mechanical piping services. All ductwork and piping systems shall be thoroughly dimensioned as to location and height above finished floor. Each different system will be drawn in a different color. Upon conclusion of the various systems coordination with the Sheet-Metal Contractor, the composite drawing shall be distributed by the Construction Manager for contractor coordination. All lighting fixture locations will be "ghosted in" by the Sheet-Metal Contractor for coordination of the same. The Sheet-Metal Contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the Sheet-Metal, HVAC Piping, Plumbing, Fire Protection, Electrical, Telecommunications and ATC firms, with the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."
>
> NOTE: The composite drawing is in addition to separate shop drawings to be submitted at the conclusion of the coordination process.

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B. At the conclusion of each composite drawing coordination process, the Construction Manager shall be notified by the Mechanical Contractor Project Manager. The Mechanical Contractor Project Manager shall then schedule an on-site coordination meeting for the purpose of signing off on the respective drawing. The Mechanical Contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.

C. The Mechanical Contractor shall print a weekly status log and maintain a file for the project on this process. Each subcontractor is responsible to submit and coordinate their work with the Construction Manager and Mechanical Contractor.

D. The Fire Protection Contractor shall overlay their complete piping system on a composite background drawing furnished by the Mechanical Contractor. The Fire Protection Contractor shall utilize a different color from that previously used by the HVAC and Plumbing draftsmen. The Fire Protection Contractor shall cooperate in the coordination process by the relocation of their piping as required to facilitate coordination. When completed, Sprinkler Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the entire coordination process, the Fire Protection Contractor shall be responsible for attending a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signatures to the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."
>
> NOTE: The composite drawing is in addition to a separate sprinkler piping shop drawing to be submitted at the conclusion of the coordination process.

E. The Electrical Contractor shall be responsible to overlay their major conduit racks and equipment, as well as verifying all lighting fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. All conduits larger than 2" shall be documented. When completed, Electrical Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Electrical Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

F. The Plumbing Contractor will be responsible to overlay their major piping racks and equipment, as well as verifying all plumbing fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Plumbing Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Plumbing Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

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"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

G. The Telecommunication Contractor will be responsible to overlay their major communication racks and cable tray, as well as verifying locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Telecommunication Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Telecommunication Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

H. Provide survey and coordination of underground plumbing for verification of location.

I. Drawings, if available, may be obtained electronically from the Architect through the Construction Manager.

J. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall receive hard copies of all drawings.

K. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall review all drawings and advise if any additional drawings are needed.

L. The Mechanical Trade Contractor shall take the lead and develop a drawing list for submissions and a submission schedule coordinated with the construction activities. The drawings shall be developed in a sequential fashion so as to no delay installation of the work or the overall project schedule. The lead Mechanical trade contractor shall include a master key plan so that the area of each drawing can be readily identified as to the location within each building. The Plumbing trade contractor shall lead the underground coordination and the HVAC trade contractor shall lead the balance of the coordination work. The drawing list and schedule shall be forwarded to the Construction Manager for review.

M. Pursuant to Construction Manager approval of the list and schedule, the Mechanical trade contractor shall provide to all participants the latest plans in a timely fashion in accordance with their schedule.

N. Prior to the start of the work, each subcontractor shall forward an insulation schedule to the Construction Manager M.E.P. Coordinator. The schedule shall show the size and thickness of each type of insulation and its intended use.

1.3 ACCESS FLOOR INSTALLATION

A. Coordination drawings for systems to be installed in the access floor shall be prepared in the same manner as described for the overhead installation.

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1.4 SHEET-METAL / PIPING / ATC / ELECTRICAL ACCESS / MAINTENANCE CLEARANCES

A. As soon as practical, the Mechanical trade contractor shall prepare layout drawings (not less than 3/8" scale) of all ductwork and piping. These drawings shall show all WALL FIRE RATINGS, registers, grilles, diffusers, and similar features, as well as locations of all valves, dampers, damper operators, and other items requiring access for maintenance. It shall also be the responsibility of the Mechanical trade contractor to show on these drawings; beams with bottom elevations, ceiling heights, wall-to-wall dimensions, partitions, columns, windows, doors, electric lighting layouts as shown on the reflected ceiling plans, acoustical ceiling grid, and other major architectural and structural features as shown on the General Construction Drawings. All dimensions should be from centerlines of columns. All required access to equipment for service and/or required for NEC code required clearances shall be shown in a dotted zone.

B. The Mechanical trade contactor, upon completion of their work, shall email their data back to the Plumbing trade contractor and copy all participants. The Plumbing trade contractor shall download the mechanical data and incorporate, by separate layer, their own routing, as well as other areas requiring access for service and maintenance to determine their relationship and possible interferences with the mechanical, architectural, or structural features to be performed as part of the work.

C. The Plumbing trade contractor shall then email their data to the Electrical trade contractor and copy all participants. The Electrical trade contractor shall download the drawing and incorporate, by separate layer, their own routings, as well as the depth of all light fixtures, access panels, etc., as required to determine the relationship and possible interferences with plumbing, mechanical, architectural, or structural items to be installed as part of the overall work. The Electrical trade contractor shall be responsible to verify that the electrical lighting layout shown on these drawings is correct and to make corrections and additions of all other light fixtures as required. In areas where no mechanical work occurs, but where other crowded electrical installations are evident, the Electrical trade contractor shall prepare similar drawings.

D. The Electrical trade contractor shall then email the Fire Protection trade contractor and copy all participants. The Fire Protection trade contractor shall download the drawing and incorporate, by separate layer, their own routings, as well as other areas requiring access for service and maintenance, to determine their relationship and possible interferences with the mechanical, electrical, plumbing, and architectural or structural items to be installed as part of the overall work.

E. The Mechanical trade contractor shall provide one composite set of reproducible drawings and forward them to the Construction Manager. This composite shall then be reviewed during meetings determined by the Construction Manager, at which all subcontractors including their subcontractors, as required by the Construction Manager, shall be represented to review, and resolve any real or apparent interference or conflicts.

F. In the preparation of all the final composite drawings, large scale details, as well as cross and longitudinal sections shall be made as required to fully delineate all conditions. Particular attention shall be given to the locations, size and clearance dimensions of equipment items, shafts, and similar features. The final composite drawings shall include the locations of all controls, tie-ins, connections for other subcontractor's work, and pipe and duct insulation as required.

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G. Final composite drawings shall then be signed off by each trade subcontractor indicating their acceptance and approval of the indicated routings and layouts and their relationship with the adjoining or contiguous work of all subcontracts. Thereafter, no unauthorized deviations shall be permitted. If deviations are made without the knowledge and agreement of Construction Manager and other affected trade contractors, the work in question shall be subject to removal and correction at no additional cost.

H. In preparing the composite drawings, minor changes in duct, pipe or conduit routings that do not affect the intended function may be made as required to avoid space conflicts, when mutually agreed. Items may not be resized, exposed items relocated, or items run exposed when not intended, without approval. No changes shall be made in any structural members or architectural features which affect the function or aesthetics of the buildings. If conflicts or interferences cannot be satisfactorily resolved, the Engineer shall be notified, and their decision obtained.

I. After final composite drawings have been accepted and approved, and signed by ALL subcontractors, the Mechanical trade contractor shall provide and distribute one sepia and two prints to each of the subcontractors, and one sepia and four prints each to Construction Manager. Subcontractors requiring further prints for their own distribution will possess sepias to accomplish same. The original signed-off mylars shall be sent to Construction Manager for permanent possession.

J. The record copies of final composite drawings shall be retained by each subcontractor as a working reference. All shop drawings, prior to their submittal to Construction Manager, shall be compared with the composite drawings and developed accordingly by the subcontractor responsible. Any revisions to the composite drawings, which may become necessary during the process of the work, shall be noted by all subcontractors, and shall be neatly and accurately recorded on the record copies. Each trade contractor shall be responsible for the up-to-date maintenance of their own record copies of the composite drawings and to keep one copy available at the site. The composite drawings and any subsequent changes thereto, shall be utilized by each subcontractor in the development of their as-built drawings. NOTE: The coordination drawings may be used with appropriate changes as as-builts and changes to title block.

K. Preparation of coordination drawings shall commence as soon as possible after award of the subcontract. The coordination drawings may lack complete data in certain instances pending receipt of equipment drawings, but sufficient space shall be allotted for the items affected. When final information is received, such data shall be promptly inserted on the composite by that trade contractor.

L. Coordination is the responsibility of all trade contractors. Construction Manager will call meetings, weekly, or as required, which subcontractors must attend to avoid delay. Failure to attend shall require the trade contractor to field run the work not coordinated. No extra compensation will be paid to any trade contractor for relocating any duct, pipe, conduit, or other material that has been installed without proper coordination. If the installation of any uncoordinated work or improper installation or coordinated work necessitates additional work by other subcontractors, at the cost of such additional work shall be assigned to the trade contractor responsible as determined by Construction Manager.

M. All changes in the work of any subcontract shall be shown on the composite drawings.

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N. All work on the coordination composite drawings shall be performed by competent CAD/BIM operators, in a clear legible manner. Each trade contractor shall execute a typical drawing activity in no more than three working days. It shall be the responsibility of each subcontractor to supply a sufficient number of CAD/BIM operators so as not to delay the coordination process. Construction Manager and Engineer shall be the judge of the acceptability of the drawings.

O. The composite drawings shall not be used for as-built drawings. (See Paragraph above)

P. It shall be further understood that each trade contractor's specified submittals shall be transmitted for approval during the coordination period in order that the project encounter no delays.

Q. The Mechanical trade subcontractor shall pre-coordinate all control equipment locations with the designated ATC trade subcontractor and indicate it on the composite document.

1.5 REQUIREMENTS

A. All Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC trade contractors shall be required to use AutoCad (CAD) or 3D BIM format. Coordination drawings shall be distributed via email or diskettes. ALL EMAILS SHALL BE COPIED TO CONSTRUCTION MANAGER, ENGINEER, AND PROJECT MANAGER.

B. The Sheet-Metal trade contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the sheet-metal, HVAC, piping, plumbing, sprinkler, electrical and ATC firms with the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

C. The Mechanical trade contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.

D. The Mechanical Contractor shall print a weekly status of all emails sent and received and maintain a hard copy file for use at the coordination "sign-off" meetings. Each subcontractor is required to check emails daily.

E. Submittals: Once the coordination process has been completed, the coordination drawings shall be submitted to the Engineer for review. A single-color plot, as well as three blueprint copies of the drawings shall be submitted for review. The color plot shall delineate between the various disciplines by utilizing different color pens for each system.

PART 2 – PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION (NOT APPLICABLE)

END OF SECTION 22 00 05

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SECTION 22 05 16

EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Flexible-hose packless expansion joints.
2. Metal-bellows packless expansion joints.
3. Rubber packless expansion joints.
4. Grooved-joint expansion joints.
5. Alignment guides and anchors.
6. Pipe loops and swing connections.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. All product data from this specification shall be provided as a single submittal for review to engineer of record.

1.4 INFORMATIONAL SUBMITTALS

A. Informational submittals shall be provided from the contractor to the architect/owner for record only. They are not subject to review and approval by the engineer of record.

B. Welding certificates.

1.5 CLOSEOUT SUBMITTALS

A. Closeout submittals shall be provided from the contractor to the Owner for record only at project close-out. They are not subject to review and approval by the engineer of record.

B. Maintenance Data: For expansion joints to include in maintenance manuals.

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1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKLESS EXPANSION JOINTS

A. Flexible-Hose Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Flex-Hose Co., Inc.
   b. Mason Industries, Inc.
   c. Metraflex Company (The).
   d. Approved Equal.

2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.

   a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings in no case less than system operations pressures determined.

5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with threaded end connections.

   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings in no case less than system operations pressures determined.

6. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.

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a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings in no case less than system operations pressures determined.

7. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with flanged or welded end connections.

a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings in no case less than system operations pressures determined.

B. Metal-Bellows Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Flex-Hose Co., Inc.
b. Hyspan Precision Products, Inc.
c. Mason Industries, Inc.
d. Metraflex Company.
e. Approved equal.

2. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
3. Type: Circular, corrugated bellows with external tie rods.
4. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
5. Configuration: Single joint with base and double joint with base class(es), unless otherwise indicated.
6. Expansion Joints for Copper Tubing: Multi-ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.

a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint or threaded.
b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Solder joint or threaded.

7. Expansion Joints for Steel Piping: Multi-ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.

a. End Connections for Steel Pipe NPS 2-1/2 and Larger: Flanged or Welded.

C. Rubber Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Amber/Booth Company, Inc.; a VMC Group Company.
b. Flex-Hose Co., Inc.
c. Garlock Sealing Technologies.
d. Mason Industries, Inc.
e. Metraflex Company.
f. Approved equal.

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2. Standards: ASTM F 1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
3. Material: Fabric-reinforced rubber complying with FSA-PSJ-703.
4. Arch Type: Multiple arches with external control rods.
5. Spherical Type: Multiple spheres with external control rods.
6. Minimum Pressure Rating for NPS 1-1/2 to NPS 4: 150 psig at 220 deg F in no case less than system operations pressures determined.
7. Minimum Pressure Rating for NPS 5 and NPS 6: 140 psig at 200 deg F in no case less than system operations pressures determined.
8. Material for Water: Buna-N.
9. End Connections: Full-faced, integral steel flanges with steel retaining rings.

2.3 GROOVED-JOINT EXPANSION JOINTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Anvil International.
2. Victaulic Company.
3. Approved Equal.

B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

C. Standard: AWWA C606, for grooved joints.

D. Nipples: ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.

E. Couplings, flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for cold and hot water and bolts and nuts.

2.4 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advanced Thermal Systems, Inc.
   b. Flex-Hose Co., Inc.
   c. Hyspan Precision Products, Inc.
   d. Mason Industries, Inc.
   e. Metraflex Company.
   f. Approved Equal.

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

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1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Stud: Threaded, zinc-coated carbon steel.
    b. Expansion Plug: Zinc-coated steel.
    c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
    c. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
    d. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

C. Install rubber packless expansion joints according to FSA-PSJ-703.

D. Install grooved-joint expansion joints to grooved-end steel piping.

E. Install isolation valves on inlet and outlet of expansion joints.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

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3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install two guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 22 05 16

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SECTION 22 05 17

SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Grout.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1. All product data from this specification shall be provided as a single submittal for review to engineer of record.

1.4 INFORMATIONAL SUBMITTALS

A. Informational submittals shall be provided from the contractor to the architect/owner for record only. They are not subject to review and approval by the engineer of record.

1.5 CLOSEOUT SUBMITTALS

A. Closeout submittals shall be provided from the contractor to the Owner for record only at project close-out. They are not subject to review and approval by the engineer of record.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

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B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

C. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Jay R. Smith Mfg. Co.
2. Zurn Industries, LLC.
3. Approved Equal.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT Industries.
4. Metraflex Company.
5. Proco Products, Inc.
6. Approved Equal.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.4 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

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D. Packaging: Premixed and factory packaged.

2.5 FIRE STOPPING – GENERAL

A. All penetrations through fire-resistance-rated floor, fire resistance rated, floor/ceiling assemblies and roof construction and through fire-resistance-rated walls, and partitions shall be fire stopped.

B. Penetrations to be fire stopped include both empty openings and those containing cables, pipes, ducts, conduits, and any other items.

C. Fire rating of sealed penetrations shall meet or exceed the rating of the assembly being penetrated.

D. Materials shall be installed in accordance with manufacturer's recommendations and their UL listing.

E. Penetrations in Fire Resistance Rated Walls: Provide firestopping with ratings determined in accordance with UL 1479 or ASTM E 814.

F. F-Rating: Not less than the fire-resistance rating of the wall construction being penetrated.

G. Penetrations in Horizontal Assemblies: Provide firestopping with ratings determined in accordance with UL 1479 or ASTM E 814.

H. F-Rating: Minimum of 1-hour rating, but not less than the fire-resistance rating of the floor construction being penetrated.

I. T-Rating: When penetration is located outside of a wall cavity, minimum of 1-hour rating but not less than the fire-resistance rating of the floor construction being penetrated.

J. W-Rating: Class 1 rating in accordance with water leakage test per UL 1479.

K. Penetrations in Smoke Barriers: Provide firestopping with ratings determined in accordance with UL 1479 or ASTM E 814.

L. L-Rated: Not exceeding 5.0 cfm/sq. ft. of penetration opening at both ambient and elevated temperatures.

M. Mold Resistance: Provide penetration firestopping with mold and mildew resistance rating of 0 as determined by ASTM G21.

2.6 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with through penetration firestop systems (XHEZ), joint systems (XHBN), and perimeter firestop systems (XHDG) listed in Volume 2 of the UL Fire Resistance Directory; provide products of the following manufacturers as identified below:

1. Hilti, Inc.
2. Approved Equal.

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2.7 MATERIALS

A. Use only firestop products that have been UL 1479 or ASTM E 814 tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire-rating involved for each separate instance.

B. Pre-installed firestop devices for use with noncombustible and combustible pipes (closed and open systems) penetrating concrete floors and/or gypsum walls, the following products are acceptable:

1. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic or polypropylene sleeve lined with an intumescent strip., and extended rectangular flange attached to one end of the sleeve for fastening to concrete formwork and a neoprene gasket. Cast-in-place devices for use with only noncombustible penetrations shall be black in color. Cast-in devices for use with combustible or noncombustible penetrations shall be red in color.
2. Hilti Cast-In Place Firestop Device (CP 680-P) for use with combustible penetrants.
3. Hilti Cast-In Place Firestop Device (CP 680-M) for use with noncombustible penetrants.
4. Drop-In Firestop Devices: Factory-assembled-devices for use with combustible or noncombustible penetrations in cored holes within concrete floors. Device shall consist of galvanized steel sleeve lined with an intumescent strip, an extended rectangular flange attached to one end of the sleeve for fastening to concrete floor, and neoprene gasket.
5. Hilti Firestop Drop-In Device (CFS-DID) for use with noncombustible and combustible penetrations.
6. Blocks/Plugs: Intumescent flexible block/plug suitable for reuse in re-penetration of openings. Blocks shall allow up to 12” of unreinforced annular space.

    a. Hilti Firestop Block (CFS-BL)

8. Tub Box Kit: Cast-in-place pre-formed plastic tub box kit with three support legs for use with drain piping assembly associated with bathtub installations.

    a. Hilti Tub Box Kit (CP 681)

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

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1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.
    a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

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3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves.
b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves.

2. Exterior Concrete Walls below Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

c. Piping NPS 6 and Larger: Galvanized-steel wall sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

c. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.

5. Interior Partitions:

a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 22 05 17

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SECTION 22 05 19

METERS AND GAUGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 COMMISSIONING: Each contractor and vendor shall be part of a total building and system commissioning effort as conducted by the Commissioning Agent. Each contractor shall provide a technician and tools required to assist and facilitate the commissioning agent, as outlined by the commissioning plan. Vendor of the equipment shall also participate in the commissioning efforts. Full scope of work and all related responsibilities will be defined in Commissioning documentation.

1.2 SUMMARY

A. Section Includes:

1. Liquid-in-glass thermometers.
2. Pressure gages.
3. Gage attachments.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

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a. Trerice, H. O. Co.

b. Weksler Glass Thermometer Corp
c. Approved Equal.

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 6-inch nominal size.
4. Case Form: Straight unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass or plastic.
8. Stem: Aluminum or brass and of length to suit installation.

a. Design for Thermowell Installation: Bare stem.

9. Connector: 3/4 inch, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Ashcroft Inc.
b. Trerice, H. O. Co.
c. Weiss Instruments, Inc.
d. Weksler Glass Thermometer Corp.
e. Approved Equal.

2. Standard: ASME B40.100.
3. Case: Liquid-filled Sealed Solid-front, pressure relief type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Metal.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

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2.3 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

B. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

C. Install valve and snubber in piping for each pressure gage for fluids.

D. Install thermometers in the following locations:

1. Inlet and outlet of each water heater.

E. Install pressure gages in the following locations:

1. Suction and discharge of each domestic water pump and RO System.

F. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

G. Install flowmeter in accessible positions in piping system.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow space for service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Hot-Water Piping: 0 to 250 deg F.

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3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Service Piping: 0 to 100 psi.

3.6 COMMISSIONING

A. The installing contractor shall provide a field technician and specialized tools to facilitate a successful site system commissioning and testing for all equipment and systems. This contractor and technician shall be part of the overall commissioning team. Where applicable and required, the contractor shall secure and pay for a factory technician to be part of the startup, testing and commissioning team and efforts.

1. All equipment shall be commissioned, and the operation of that equipment shall be checked by the installing contractor. Specific systems shall be commissioned when more than one contractor is involved in the installation or there is multiple system interface and control involved with that piece of equipment.
2. The contractors shall check and verify all equipment nameplate data against the design parameters, prior to installation.
3. The contractors shall submit a Spare Parts List for all equipment in the Maintenance and Operations Manuals to include, but not limited to the following:

a. Part Numbers
b. Part and Equipment Description
c. Quantity of Parts Required
d. Lubrication Requirements
e. Full Warranty Information
f. Complete Operation and Maintenance Manuals

END OF SECTION 22 05 19

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SECTION 22 05 23

VALVES AND SPECIALTIES FOR PLUMBING PIPING

PART 2 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

2.2 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. Iron gate valves.
3. Bronze swing check valves.
4. Iron swing check valves.
5. Iron, center-guided check valves.
6. Balancing valves.
7. Strainers.
8. Drain valves.
9. Water-hammer arresters.
10. Air vents.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. NRS: Non-rising stem.

C. OS & Y: Outside screw and yoke.

D. RS: Rising stem

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. All product data from this specification shall be provided as a single submittal for review to engineer of record.
2. Certification that products comply with NSF 61 Annex G and NSF 372.

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2.5 INFORMATIONAL SUBMITTALS

A. Informational submittals shall be provided from the contractor to the architect/owner for record only. They are not subject to review and approval by the engineer of record.

2.6 CLOSEOUT SUBMITTALS

A. Closeout submittals shall be provided from the contractor to the Owner for record only at project close-out. They are not subject to review and approval by the engineer of record.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
1. Protect threads, flange faces, and soldered ends.
2. Set ball valves open to minimize exposure of functional surfaces.
3. Set gate valves closed to prevent rattling.
4. Set check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

PART 2 – PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on steel valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for solder-joint connections.
6. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 Annex G and NSF 372 for valve materials for potable-water service.

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D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:

1. Handlever: For quarter-turn valves smaller than NPS 4.

H. Valves in Insulated Piping:

1. Include 2-inch stem extensions.
2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

I. RS Valves in Insulated Piping: With 2-inch stem extensions.

J. Valve Bypass and Drain Connections: MSS SP-45

2.2 BRASS BALL VALVES

A. Two-Piece, Brass Ball Valves with Full Port and Brass Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Milwaukee Valve Company.
b. NIBCO INC.
c. Red-White Valve Corporation.
d. Stockham; Crane Energy Flow Solutions.
e. Watts; a Watts Water Technologies company.
f. Approved Equal.

2. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig.
c. Body Design: Two piece.
d. Body Material: Forged brass.
e. Ends: Threaded and soldered.
f. Seats: PTFE.
g. Stem: Brass.
h. Ball: Chrome-plated brass.
i. Port: Full.

B. Three-Piece, Brass Ball Valves with Full Port and Brass Trim:

NOT FOR BIDDING PURPOSES

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. NIBCO INC.
    b. Red-White Valve Corporation.
    c. Stockham; Crane Energy Flow Solutions.
    d. Watts; a Watts Water Technologies company.
    e. Approved Equal.

2. Description:

    a. Standard: MSS SP-110.
    b. CWP Rating: 600 psig.
    c. Body Design: Three piece.
    d. Body Material: Forged brass.
    e. Ends: Threaded and soldered.
    f. Seats: PTFE.
    g. Stem: Brass.
    h. Ball: Chrome-plated brass.
    i. Port: Full.

2.3 BRONZE SWING CHECK VALVES

B. Class 125, Bronze, Swing Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Milwaukee Valve Company.
    b. NIBCO INC.
    c. Red-White Valve Corporation.
    d. Stockham; Crane Energy Flow Solutions.
    e. Watts; a Watts Water Technologies company.
    f. Approved Equal.

2. Description:

    a. Standard: MSS SP-80, Type 3.
    b. CWP Rating: 200 psig.
    c. Body Design: Horizontal flow.
    d. Body Material: ASTM B 62, bronze.
    e. Ends: Threaded or soldered. See valve schedule articles.
    f. Disc: Bronze.

2.4 IRON SWING CHECK VALVES

B. Class 125, Iron Swing Check Valves with Metal Seats:

NOT FOR BIDDING PURPOSES

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Milwaukee Valve Company.
    b. NIBCO INC.
    c. Red-White Valve Corporation.
    d. Stockham; Crane Energy Flow Solutions.
    e. Watts; a Watts Water Technologies company.
    f. Approved Equal.

2. Description:

    a. Standard: MSS SP-71, Type I.
    b. CWP Rating: 200 psig.
    c. Body Design: Clear or full waterway.
    d. Body Material: ASTM A 126, gray iron with bolted bonnet.
    e. Ends: Flanged or threaded. See valve schedule articles.
    f. Trim: Bronze.
    g. Gasket: Asbestos free.

2.5 IRON GATE VALVES

A. Class 125, OS&Y, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Milwaukee Valve Company.
    b. NIBCO INC.
    c. Red-White Valve Corporation.
    d. Stockham; Crane Energy Flow Solutions.
    e. Watts; a Watts Water Technologies company.
    f. Approved Equal.

2. Description:

    a. Standard: MSS SP-70, Type I.
    b. CWP Rating: 200 psig.
    c. Body Material: Gray iron with bolted bonnet.
    d. Ends: Flanged.
    e. Trim: Bronze.
    f. Disc: Solid wedge.
    g. Packing and Gasket: Asbestos free.

2.6 IRON, CENTER-GUIDED, SPRING-LOADED CHECK VALVES

B. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

NOT FOR BIDDING PURPOSES

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Milwaukee Valve Company.
    b. NIBCO INC.
    c. Red-White Valve Corporation.
    d. Stockham; Crane Energy Flow Solutions.
    e. Watts; a Watts Water Technologies company.
    f. Approved Equal.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 200 psig.
    c. Body Material: ASTM A 126, gray iron.
    d. Style: Compact wafer, spring loaded.
    e. Seat: Bronze.

C. Class 125, Iron, Globe, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Milwaukee Valve Company.
    b. NIBCO INC.
    c. Red-White Valve Corporation.
    d. Stockham; Crane Energy Flow Solutions.
    e. Watts; a Watts Water Technologies company.
    f. Approved Equal.

2. Description:

    a. Standard: MSS SP-125.
    b. CWP Rating: 200 psig.
    c. Body Material: ASTM A 126, gray iron.
    d. Style: Globe, spring loaded.
    e. Ends: Flanged.
    f. Seat: Bronze.

2.7 BALANCING VALVES

B. Memory-Stop Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Milwaukee Valve Company.
    b. NIBCO INC.
    c. Bell & Gossett
    d. Approved Equal.

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2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: NPS 2 or smaller.
5. Body: Copper alloy.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.
10. Handle: Vinyl-covered steel with memory-setting device.

2.8 STRAINERS FOR DOMESTIC WATER PIPING

B. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:

    a. Strainers NPS 2 and Smaller: 0.020 inch.
    b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
    c. Strainers NPS 6 and Larger: 0.10 inch.

6. Drain: Factory-installed, hose-end drain valve.

2.9 DRAIN VALVES

B. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

C. Gate-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-80 for gate valves.
2. Pressure Rating: Class 125.
3. Size: NPS 3/4.
4. Body: ASTM B 62 bronze.
5. Inlet: NPS 3/4 threaded or solder joint.

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6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.10 WATER-HAMMER ARRESTERS

B. Water-Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Jay R. Smith Mfg. Co.
b. Josam Company.
c. Precision Plumbing Products.
d. Sioux Chief Manufacturing Company, Inc.
e. Watts; a Watts Water Technologies company.
f. Approved Equal.

2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.11 AIR VENTS

B. Bolted-Construction Automatic Air Vents:

1. Body: Bronze.
2. Pressure Rating and Temperature: 125-psig minimum pressure rating at 140 deg F.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 1/2 minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

C. Welded-Construction Automatic Air Vents:

1. Body: Stainless steel.
2. Pressure Rating: 150-psig minimum pressure rating.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 3/8 minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

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B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace them with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

F. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
3. Do not install bypass piping around backflow preventers.

G. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

H. Install balancing valves in locations where they can easily be adjusted.

I. Where installing non-adjustable or adjustable balancing valves, install a combination of non-adjustable or adjustable balancing valves in conjunction with memory stop type balancing valves as recommended by the manufacturer.

J. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.

K. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.

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L. Install outlet boxes recessed in wall or surface mounted on wall. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs.

M. Install water-hammer arresters in water piping according to PDI-WH 201.

N. Install air vents at high points of water piping. Install drain piping and extend to appropriate location.

O. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

3.3 CONNECTIONS

B. Comply with requirements for ground equipment in Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 FIELD QUALITY CONTROL

B. Perform the following tests and inspections:

1. Test each reduced-pressure-principle backflow preventer, double-check, backflow-prevention assembly according to authorities having jurisdiction and the device's reference standard.

C. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and performing balancing. Replace valves if persistent leaking occurs.

B. Set field-adjustable pressure set points of water pressure-reducing valves.

C. Set field-adjustable flow set points of balancing valves and provide balancing report.

D. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

3.6 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. Use gate valves for shutoff service only.

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C. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.

3.7 PUMP-DISCHARGE CHECK VALVE SCHEDULE:

A. NPS 2 and Smaller: Bronze swing check valves with bronze disc.

B. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight or spring; or iron, center-guided, metal-seat check valves.

3.8 DOMESTIC HOT- AND COLD-WATER BALL VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Two-piece, brass ball valves with full port and brass trim.

B. Pipe NPS 2-1/2 and Larger:

1. Three-piece, brass ball valves with full port and brass trim.

3.9 DOMESTIC HOT- AND COLD-WATER GATE VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger: Iron gate valves, OS&Y with flanged ends.

3.10 DOMESTIC HOT- AND COLD-WATER CHECK VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze swing check valves, bronze disc with soldered or threaded end connections.

B. Pipe NPS 2-1/2 and Larger:

1. Iron, center-guided check valves, globe, metal seat with threaded or flanged end connections.

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SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01, Division 03 and Division 05 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal-hanger shield inserts.
4. Fastener systems.
5. Pipe stands.
6. Equipment supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

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1. All product data from this specification shall be provided as a single submittal for review to engineer of record.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details with specific anchoring product details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

1.6 INFORMATIONAL SUBMITTALS

A. Informational submittals shall be provided from the contractor to the architect/owner for record only. They are not subject to review and approval by the engineer of record.

B. Welding certificates.

1.1 CLOSEOUT SUBMITTALS

A. Closeout submittals shall be provided from the contractor to the Owner for record only at project close-out. They are not subject to review and approval by the engineer of record.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

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2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.
6. Pipe Shields Inc.
7. Approved Equal.

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.4 FASTENER SYSTEMS

A. Per ACI 318, for safety related attachments, such as sprinkler systems and heavy suspended pipes, all anchors shall assume the cracked concrete design condition. Anchors with an ICC approval for cracked concrete shall be used.
Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used. Basis of Design: Hilti X-W6 or X-W10 Carbon Steel Threaded Studs (ICC-ESR 1663), or equal

B. Cast-in-Anchors

1. Wood Form concrete cast-in-anchor. Steel internally threaded headed cast-in inserts which receive threaded insert elements such as threaded rods and bolts ½ inch, 3/8 inch, ½ inch 5/8 inch and ¾ inch in diameters.

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b. Basis of Design: Hilti Kwik-Cast KCD-WF sing thread, Hilti\ Kwik-Cast KCM-WF (ICC-ESR 4145), or equal.
c. Interior Use: Unless otherwise indicated on the drawings, provide carbon-steel anchors with zinc plating equivalent to minimum 5.1 um (.0002 inch) zinc coating.
d. Anchors to be color coded to indicate internal thread diameter.

1. Concrete over Metal Deck cast-in-anchor: Steel internally threaded headed cast-in inserts which receive threaded insert elements such as threaded rods and bolts ½ inch, 3/8 inch, ½ inch, 5/8 inch and ¼ inch diameters.

a. Basis of Design: Hilti Kwik-Cast KCS-MD single thread insert (ICC-ESR 4145), or equal.
b. Interior Use: Unless otherwise indicated on the Drawings, provide carbon steel anchors with zinc plating equivalent to minimum 5.1 µm (.0002 inch) zinc coating.
c. Anchors to be color coded to indicate internal thread diameter.

3. Concrete cast-in anchor in Pan Deck form: Steel internally threaded headed cast-in inserts which receive threaded insert elements such as threaded rods and bolts ½-inch, 3/8-inch, ½-inch, 5/8-inch and ¾-inch diameters.

a. Basis of Design: Hilti Kwik-Cast KCM-PD multi thread for pan deck (ICC-ESR 4145), or equal.
b. Interior Use: Unless otherwise indicated on the Drawings, provide carbon steel anchors with zinc plating equivalent to minimum 5.1 µm (.0002 inch) zinc coating.
c. Anchors to be color coded to indicate internal thread diameter

C. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated-steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Basis of Design: Hilti Kwik Bolt TZ2 (ICC-ESR 4266), or equal
2. Indoor Applications: Unless otherwise indicated on the Drawings, provide carbon steel anchors with zinc plating in accordance with ASTM B633, Type III Fe/Zn 5 (SC1).
3. Outdoor Applications: As indicated on the Drawings, provide stainless steel anchors. Stainless steel anchors shall be AISI [Type 304] [and] [Type 316] stainless steel provided with stainless steel nuts and washers of matching alloy group and minimum proof stress equal to or greater than the specified minimum full-size tensile strength of the externally threaded fastener. Stainless steel nuts shall conform to ASTM F594 unless otherwise specified. Avoid installing stainless steel anchors in contact with galvanically dissimilar metals.

D. Screw Anchors: Insert screw type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Basis of Design: Hilti Kwik-HUS EZ, Hilti Kwik-HUS EZ I (ICC-ESR 3027), or equal
2. Indoor Applications: Unless otherwise indicated on the Drawings, provide carbon steel anchors with zinc plating in accordance with ASTM B633, Type III Fe/Zn 5 (SC1).

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3. Outdoor Applications: As indicated on the Drawings, provide stainless steel anchors. Stainless steel anchors shall be AISI [Type 304] [and] [Type 316] stainless steel provided with stainless steel nuts and washers of matching alloy group and minimum proof stress equal to or greater than the specified minimum full-size tensile strength of the externally threaded fastener. Stainless steel nuts shall conform to ASTM F594 unless otherwise specified. Avoid installing stainless steel anchors in contact with galvanically dissimilar metals.

E. Rod Hanger and Cable Wire Hanger Assemblies.

1. Hanger Rods Assemblies: Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

   a. Basis-of-Design Product: Subject to compliance with requirements, provide Hilti HAS rods and associated nuts and washers

2. Cable Hanging System Hilti “X-MW MX” and “X-MW ALH” (ICC-ESR 2795). Combination of power-actuated fastener and wire rope with factory crimped end fixing on one end.

   a. Basis-of-Design Product: Subject to compliance with requirements, provide Hilti, Inc.; Hilti X-MW Mechanical / Electrical Clips and Hangers Product Technical Guide Supplement

3. Cable Hanging System Hilti “MW-EB” and “MW-LP”. Combination of cast in place or post installed Hilti fastener and wire rope with factory eyebolt or loop end fixing on one end.

   a. Basis-of-Design Product: Subject to compliance with requirements, provide Hilti, Inc.; Modular Support Technical Guide Supplement Wire Systems
   b. PIPE STANDS

F. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

G. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

H. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.

I. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Plastic.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

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J. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

K. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.5 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

B. Where non welded support structures are acceptable, modular channel and girder support shall be the Hilti MT System, designed, supplied, and assembled in accordance with manufacturers' instructions.

2.6 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.

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2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:

1. Attach clamps and spacers to piping.

a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.

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b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
b. NPS 4: 12 inches long and 0.06 inch thick.
c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.

5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.

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4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports or metal trapeze pipe hangers and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
3. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
4. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
5. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
6. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.

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7. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
9. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
10. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
11. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
12. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
13. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
14. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
15. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
16. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
17. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
18. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
19. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

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L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.

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4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

R. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 22 05 29

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SECTION 22 05 48

VIBRATION CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient support.
9. Resilient pipe guides.
10. Elastomeric hangers.
11. Spring hangers.
12. Snubbers.
13. Restraints - rigid type.
14. Restraints - cable type.
15. Restraint accessories.
16. Post-installed concrete anchors.
17. Concrete inserts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. All product data from this specification shall be provided as a single submittal for review to engineer of record.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal:

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1. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

1.3 INFORMATIONAL SUBMITTALS

A. Informational submittals shall be provided from the contractor to the architect/owner for record only. They are not subject to review and approval by the engineer of record.

B. Coordination Drawings: Show coordination of vibration isolation device installation for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

C. Welding certificates.

1.4 QUALITY ASSURANCE

A. Closeout submittals shall be provided from the contractor to the Owner for record only at project close-out. They are not subject to review and approval by the engineer of record.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7 and be acceptable to authorities having jurisdiction.

C. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design system.

B. Fire/Smoke Resistance: All components that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL in accordance with ASTM E84 or UL 723 and be so labeled.

C. Component Supports:

1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.
2. All component support attachments must comply with force and displacement resistance requirements of ASCE/SEI 7-16 Section 13.6.

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2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Minimum deflection as indicated on Drawings.
4. Pad Material: Oil- and water-resistant rubber.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.
7. Sandwich-Core Material: Resilient and elastomeric.

a. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Elastomeric Isolation Mounts:

1. Mounting Plates:

a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
c. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

2. Minimum deflection as indicated on Drawings.
3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

1. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

a. Housing: Cast-ductile iron or welded steel.
b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2. Minimum deflection as indicated on Drawings.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:

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1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psi.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
7. Minimum deflection as indicated on Drawings.

2.6 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Minimum deflection as indicated on Drawings.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
    b. Top housing with attachment and leveling bolt.

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:

1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

    a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
    b. Top plate with threaded mounting holes.
    c. Internal leveling bolt that acts as blocking during installation.

2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

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7. Minimum deflection as indicated on Drawings.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:

1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.

   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
   b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum deflection as indicated on Drawings.

2.9 PIPE-RISER RESILIENT SUPPORT

A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch-Thick Neoprene:

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psi on isolation material providing equal isolation in all directions.
3. Minimum deflection as indicated on Drawings.

2.10 RESILIENT PIPE GUIDES

A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch-Thick Neoprene:

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

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1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
2. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.
3. Minimum deflection as indicated on Drawings.

2.12 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Minimum deflection as indicated on Drawings.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.13 SNUBBERS

A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be prequalified in accordance with ACI 355.2 testing and designated in accordance with ACI 318-14 Ch. 17 for 2015 or 2018 IBC.
2. Preset Concrete Inserts: Prequalified in accordance with ICC-ES AC446 testing.
3. Anchors in Masonry: Design in accordance with TMS 402.
4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
5. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.14 RESTRAINTS - RIGID TYPE

A. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building

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structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.15 RESTRAINTS - CABLE TYPE

A. Restraint Cables: ASTM A492 stainless steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.

B. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19-16. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.16 RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.17 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:

1. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:

1. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

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C. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7-16, Ch. 13.

1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

2.18 CONCRETE INSERTS

A. Provide preset concrete inserts that are prequalified in accordance with ICC-ES AC466 testing.

B. Comply with ANSI/MSS SP-58.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to wind load forces.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static forces within specified loading limits.

3.2 INSTALLATION OF VIBRATION-CONTROL DEVICES

A. Provide vibration-control devices for systems and equipment where the Specifications indicate they are to be installed on specific equipment and systems.

B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

C. Installation of vibration isolators must not cause any stresses, misalignment or change of position of equipment or piping.

D. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

E. Equipment Restraints:

1. Install snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

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2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

F. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

G. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

H. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

I. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

J. Post-Installed Concrete Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify Project structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL MOTION

A. Provide flexible connections in piping systems where they cross structural joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7.

3.4 ADJUSTING

A. Adjust isolators after system is at operating weight.

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B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 22 05 48

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SECTION 22 05 53

IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Pipe labels.
3. Valve tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1. All product data from this specification shall be provided as a single submittal for review to engineer of record.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 INFORMATIONAL SUBMITTALS

A. Informational submittals shall be provided from the contractor to the architect/owner for record only. They are not subject to review and approval by the engineer of record.

1.5 CLOSEOUT SUBMITTALS

A. Closeout submittals shall be provided from the contractor to the Owner for record only at project close-out. They are not subject to review and approval by the engineer of record.

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PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Brady Corporation.
    b. Brimar Industries, Inc.
    c. Craftmark Pipe Markers.
    d. emedco.
    e. Seton Identification Products.
    f. Approved Equal.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch-thick, and having predrilled holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Red.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Brady Corporation.
    b. Brimar Industries, Inc.
    c. Craftmark Pipe Markers.
    d. emedco.
    e. Seton Identification Products.

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f. Approved Equal.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.3 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Brimar Industries, Inc.
c. Craftmark Pipe Markers.
d. emedco.
e. Seton Identification Products.
f. Approved Equal.

B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain or beaded chain.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

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PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Pipe Label Color Schedule:

1. Domestic Water Piping

a. Background: Safety green.

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b. Letter Colors: White.

2. Sanitary Waste and Storm Drainage Piping:

a. Background Color: Safety black.
b. Letter Color: White.

3. Natural Gas Piping:

a. Background Color: Safety Yellow.
b. Letter Color: Black

c. VALVE-TAG INSTALLATION

D. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

E. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

a. Cold Water: 1-1/2 inches, round.
b. Hot Water: 1-1/2 inches, round.
c. Natural Gas: 1-1/2 inches, round.

2. Valve-Tag Colors:

a. Cold Water: Natural.
b. Hot Water: Natural.
c. Natural Gas: Natural.

3. Letter Colors:

a. Cold Water: Black.
b. Hot Water: Black.
c. Natural Gas: Black.

END OF SECTION 22 05 53

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SECTION 22 07 19

PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic cold-water piping
3. Domestic recirculating hot-water piping.
4. Horizontal sanitary piping and traps above grade receiving condensate.
5. Horizontal sanitary piping and traps above grade serving mechanical room floor drains.
6. Horizontal storm-water piping above grade.
7. Roof drains bodies.
8. Supplies and drains for handicap-accessible lavatories and sinks.

1.2 DEFINITIONS

A. Thermal Conductivity (k value): The amount of heat in BTUs transferred in one hour through one square foot of homogeneous material one-inch in thickness when there is a temperature difference of 1°F.

B. Compression Fit Method: To allow for expansion and contraction of elastomeric sheet and roll insulation, leave a 1/2" -wide uncoated border at the butt-edge seams on the surface to be insulated and the insulation surface. Overlap the insulation 1/4" at the butt-edge and compress the edges into place. Apply adhesive to the butt-edges of the insulation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Must include thermal conductivity, water-vapor permeance, thickness, and jackets (both factory and field applied, if any).

1. All product data from this specification shall be provided as a single submittal for review to engineer of record.

1.4 INFORMATIONAL SUBMITTALS

A. Informational submittals shall be provided from the contractor to the architect/owner for record only. They are not subject to review and approval by the engineer of record.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation

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materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

1.5 CLOSEOUT SUBMITTALS

A. Closeout submittals shall be provided from the contractor to the Owner for record only at project close-out. They are not subject to review and approval by the engineer of record.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training. Preference will be given to those who have successfully completed a manufacturer's installation training program, such as the 'Armacell Qualified Installer Program' (AQIP) or similar.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

C. Material shall be stored in a clean, dry indoor space that provides protection against the weather.

D. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Supply and Drain Protective Shielding Guards: ICC A117.1.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule", and “Outdoor, Aboveground Piping Insulation Schedule," articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

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E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Grade 1, Type I for tubular materials.

1. Basis of Design Products: AC Accoflex, AP Armaflex, AP Armaflex Black Lap Seal.
2. Materials shall be black in color.
3. Materials shall have a flame spread and smoke developed index as specified above.
4. Materials shall have a maximum thermal conductivity of 0.28 BTU-in/h-ft^2-^{o}F at a 75^{o}F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revision.
5. Materials shall have a maximum water vapor transmission of 0.08 perm-inches when tested in accordance with ASTM E96, Procedure A, latest revision.

G. Glass-Fiber, Performed Pipe: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 850 deg F in accordance with ASTM C411. Comply with ASTM C5447.

2. Performed Pipe Insulation: Grade A with factory-applied ASJ.
3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
4. Factory-applied jacket requirements are specific in “Factory-Applied Jackets” Article.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Adhesives shall not detract from the system flame spread/smoke developed ratings as specified above.

C. Flexible Elastomeric

1. Adhesive shall comply with MIL-A-24179A, Type II, Class I and be the insulation manufacturer’s recommended contact adhesive.

a. Basis of Design: Armaflex 520 Adhesive

2. For applications that require it, the adhesive shall have no VOC content as calculated by SCAQMD 1168 and EPA Method 24.

a. Basis of Design: Armaflex 520 BLV Adhesive

D. Glass-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.

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d. Mon-Eco Industries, Inc.
e. Approved Equal.

2. Fiberglass adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

E. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.
d. Mon-Eco Industries, Inc.
e. Approved Equal.

2. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

F. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Dow Corning Corporation; 739, Dow Silicone.
b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.
d. Speedline Corporation; Polyco VP Adhesive.

2. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.3 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

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1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.4 FIELD-APPLIED JACKETS

A. Field-applied jackets comply

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Proto Corporation; LoSmoke
   b. P.I.C. Plastics, Inc.; FG Series.
   c. Johns Manville; Zeston
   d. Speedline Corporation; SmokeSafe.
   e. Approved Equal.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White

C. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
   b. ITW Insulation Systems; Aluminum and Stainless-Steel Jacketing.
   c. RPR Products, Inc.; Insul-Mate.
   d. Approved Equal.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

   a. Sheet and roll stock ready for shop or field sizing.
   b. Finish and thickness are indicated in field-applied jacket schedules.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

   a. Sheet and roll stock ready for shop or field sizing.
   b. Material, finish, and thickness are indicated in field-applied jacket schedules.

2.5 TAPES

A. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

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1. Products: Subject to compliance with requirements, provide one of the following:

    a. ABI, Ideal Tape Division; 370 White PVC tape.
    b. Compac Corporation; 130.
    c. Venture Tape; 1506 CW NS.
    d. Approved Equal.

2. Width: 2 inches.
3. Thickness: 6 mil
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

2.6 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

1. Manufacturers: Subject to compliance with requirements, provide one of the following: Engineered Brass Company.

    a. McGuire Manufacturing.
    b. Truebro; a brand of IPS Corporation.
    c. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
    d. Approved Equal.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures:

1. Manufacturers: Subject to compliance with requirements, provide one of the following:

    a. Truebro; a brand of IPS Corporation.
    b. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
    c. Approved equal.

2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

2.7 PIPE SADDLES

A. Highly durable polymer pipe shield or saddle designed specifically for use with insulated pipes. Protection shield shall be installed between provided pipe and hanger or support.

1. The pipe saddle must come from a recognized manufacturer having a certification such as UL, ULC or CSA.
2. The minimum saddle length will be 12 "(300mm) to distribute the weight properly.
3. When the total size of the diameter of the piping and its insulation exceeds 10 inches, the minimum length of the pipe saddle must be 23".

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4. The pipe saddle must be attached to the strut channel, steel angle, H our I beam between 3'' and 9'' so as to make sure that it will not move during the installation and/or as a result of thermal expansion of insulated piping.
5. The Clevis hanger must at no time be in direct contact with non-insulated piping. The pipe saddle must be attached to the Clevis hanger to make sure that it will not move during the installation and/or as a result of thermal expansion of insulated piping.
6. The pipe saddle must have rounded sliding lips design at both ends to avoid insulation damage from thermal expansion-contraction of insulated piping.
7. The pipe saddle must have a non-adhesive surface for linear expansion of insulated piping.

    a. Armacell Insuguard Pipe Saddle
    b. Approved Equal.

2.8 PIPE SUPPORTS

A. Flexible Elastomeric

1. All pipe supports should have load-bearing PET core to support and protect the insulation from being crushed or damaged, maintaining thermal integrity of the system

    a. ArmaFix EcoLight Pipe Support
    b. Approved Equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Work shall be performed at the temperature recommended by the product manufacturer.

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3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with manufacturer’s adhesive or vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

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M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.

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2. Seal penetrations through fire-rated assemblies.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape

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insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes.

C. All pipe supports should have a load-bearing PET core to support and protect the insulation from being crushed or damaged, maintaining thermal integrity of the system.

D. Insulation Installation on Straight Piping:

1. Install pipe insulation by slitting tubular sections and applying onto piping or tubing. Alternately, whenever possible, slide un-slit sections over the open ends of piping or tubing. To avoid dust entering the pipes, tape the ends closed.
2. All seams and butt joints shall be adhered and sealed using adhesive. A thin coat of adhesive must be applied to both surfaces, allowed to tack and join both surfaces with firm pressure.
3. The insulation must be installed in compression to allow for expansion and contraction. Install an additional 1.5 inches of insulation for every six feet of installed pipe or an additional 2 percent of measured pipe length.
4. Insulation shall be pushed onto the pipe, never pulled. Stretching of insulation may result in open seams and joints.

E. Insulation Installation on Pipe Flanges:

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1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

F. Insulation Installation on Pipe Fittings, Elbows, and Tees:

1. Insulate using preformed insulation or mitered insulation made from the same density as adjacent pipe insulation.
2. Each piece shall be butted tightly against adjoining piece and bonded with adhesive.
3. Cut sectional pipe insulation to fit.

G. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

H. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket. Where pipe expansion is anticipated, detail expansion compensation for insulation on Drawings and indicate intervals for its occurrence. See the Midwest Insulation Contractors Association's "National Commercial & Industrial Insulation Standards," Plate No. 41A.

3.7 INSTALLATION OF GLASS-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

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2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

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3.9 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, wipe clean the insulation with denatured alcohol and apply two coats of insulation manufacturer's recommended protective coating. Temperature should be above 50°F during application and drying to insure good adhesion.

1. WB Armaflex Finish
2. Approved Equal.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Sanitary drainage piping not receiving condensate.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Water: Insulation shall be the following:

1. Domestic Cold Water: Glass Fiber or Flexible Elastomeric: 1/2-inch thick up to NPS 1-1/4 inches, 1/2-inch thick over NPS 1-1/4 inches.

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2. Domestic Hot Water: Glass Fiber or Flexible Elastomeric: 1 inch thick up to NPS 1-1/4 inches, 1-1/2-inch thick over NPS 1-1/4 inches.

B. Stormwater and Overflow: Insulation shall be the following:

1. Glass Fiber or Flexible Elastomeric: 1/2-inch thick.

C. Roof Drain and Overflow Drain Bodies: Insulation shall be the following:

1. Glass Fiber or Flexible Elastomeric: 1/2-inch thick.

D. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities: Insulation shall be the following:

1. Glass Fiber or Flexible Elastomeric: 1 inch thick.

E. Sanitary piping above grade serving mechanical room floor drains and all drains receiving condensate, including drain bodies, traps, and horizontal piping to stack: Insulation shall be the following:

1. Glass Fiber or Flexible Elastomeric: 1/2-inch thick.
2. Insulate floor drain body, trap and 15 feet of horizontal piping.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Exposed:

1. PVC: 20 mils thick.
2. Aluminum, Corrugated: 0.020 inch thick.

END OF SECTION 22 07 19

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SECTION 22 08 00

COMMISSIONING OF PLUMBING SYSTEMS

PART 1 . GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including General and Supplementary Conditions and other Division 1 specification sections apply to this section.

B. ASHRAE Standard 202

C. Commissioning Plan

D. Related Sections

1. Section 01 33 00 Submittal Procedures
2. Section 01 42 00 References
3. Section 01 78 23 Operations and Maintenance Data
4. Section 01 78 39 Project Record Documents
5. Section 01 79 00 Demonstration and Training
6. Section 01 91 13 General Commissioning Requirements
7. Division 22 requirements for work in those Sections
8. Section 22 08 00 Commissioning of Plumbing Systems
9. Division 23 requirements for work in those Sections
10. Section 23 08 00 Commissioning of Mechanical Systems
11. Section 26 08 00 Commissioning of Electrical Systems
12. Division 28 requirements for work in those sections

1.2 SUMMARY

A. Section includes commissioning process requirements for Plumbing systems, assemblies, and equipment.

B. The commissioning process does not remove or reduce the responsibility of the contractor to provide a finished and fully functioning product. Commissioning should not add to the overall work effort. Commissioning puts a focus on following standard installation and startup procedures, documenting them, resolving issues in a timely manner, verifying the Owner's Project Requirements through equipment, system and integrated system testing, to permit a smooth turnover and acceptance at the end of the project.

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1.3 DESCRIPTION

A. Commissioning: Commissioning is a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meet defined objectives and criteria. The Commissioning process begins at project inception (during the pre-design phase) and continues through the life of the facility. The commissioning process includes specific tasks to be conducted during each phase in order to verify that design, construction, and training meets the owner's project requirements.

B. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:

1. Verify that applicable equipment and systems are installed according to the contract documents, manufacturer's recommendations, and industry accepted minimum standards and those they receive adequate operational checkout by installing contractors.
2. Verify and document proper performance of equipment and systems.
3. Verify that O&M documentation left on site is complete.
4. Verify that the owner's operating personnel are adequately trained.

1.4 COORDINATION

A. Coordinate all sub-trades, other divisions, manufacturers, suppliers, and other specialists as required to ensure all phases of work shall be properly organized prior to commencement of each particular startup, testing and commissioning procedure.

B. Coordinate the activities of this Section with the Commissioning requirements of:

1. Division 1
2. Division 22
3. Division 23
4. Division 26
5. Other equipment and systems testing specified in this and other Divisions.

C. Where any equipment or systems require testing prior to starting, ensure that such work has been completed and approved prior to starting of the equipment and or systems.

1.5 RESPONSIBILITIES

A. The Plumbing Commissioning process for the vendors/subcontractors consists of:

1. Facilitate the coordination of commissioning and provide to the General Contractor (GC) commissioning activities for incorporation into the Overall Project Schedule (OPS).
2. Provide detailed startup procedures.
3. Include the cost of commissioning in the total contract price.
4. Ensure that all subcontractors and vendors execute their commissioning responsibilities according to the contract documents and the OPS.
5. Provide copies of all submittals as required in Section 01 33 00 including all changes thereto.

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6. Attend and participate in commissioning team meetings held as necessary throughout the construction and acceptance phases.
7. Provide the training of owner personnel.
8. Review and perform Pre-Functional Checklists (PFC) provided by the CxP.
9. Provide test reports as required by Division 21, 22, 23, and 26 to the CxP for review.
10. Cooperate with the CxP for resolution of issues recorded in the Issues Log.
11. Perform work associated with deficiencies identified on the Issues Log and during Functional Performance Testing.
12. Prepare O&M manuals, according to the contract documents, including clarifying and updating the original sequences of operation to as-built/as-tested conditions.
13. Provide assistance for seasonal or deferred performance testing.
14. Ensure that subcontractors correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
15. Perform all guarantees work for materials furnished under the contract for the time specified in the contract, including all warranties and curing all latent defects within the time period provided in the contract.

1.6 SUBMITTALS

A. Refer also to Specification Section 01 91 13, Subsection 1.8.

B. Provide the CxP a copy of the following items, for the systems to be commissioned:

1. Equipment and System Submittals to include, at a minimum, the following:

    a) Cut sheets
    b) Performance data

2. Manufacturer's pre-startup checklists

    a) Manufacturer's start-up checklist

3. Installation Instructions
4. Shop Drawings (including any resubmittals required by the A/E)
5. Testing plan
6. Completed field test report, including all completed forms and checklists, and list of all outstanding deficiencies and uncompleted items.
7. Operational and maintenance documentation
8. Training plan and training materials
9. As-built documentation

1.7 EQUIPMENT/SYSTEMS TO BE COMMISSIONED

A. The plumbing systems to be commissioned are listed in the Commissioning Plan with roles and responsibilities listed in Part 3 of 22 08 00.

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PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Provide two-way radios, ladders and other equipment as required to complete the commissioning program as outlined in this specification.

B. Provide all safety equipment required for personnel involved in the Commissioning program.

C. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division.

D. All test and measurement instruments shall have been calibrated within the calendar year prior to testing by an independent metrology laboratory using industry standards and methods.

PART 3 - EXECUTION

3.1 MEETINGS

A. Attend as required by section 01 91 13, Subsection 3.1.

3.2 STARTUP, CONSTRUCTION CHECKLISTS, AND INITIAL CHECKOUT

A. Provide as required by section 01 91 13.

B. The subcontractors and vendors shall execute startup and provide the CxP and A/E, through the owner, with a signed and dated copy of the completed startup and construction checklists.

C. Only individuals of the subcontractor (technicians, engineers, tradesmen, vendors, etc.) who have direct knowledge and witnessed that a line-item task on the construction checklist was actually performed shall check off that item. It is acceptable for witnessing supervisors to fill out these forms.

D. The contractor submits the full startup plan to the CxP for review and approval.

E. The CxP reviews and approves the procedures and the format for documenting them, noting any plans that need to be added.

3.3 FUNCTIONAL PERFORMANCE TESTING

A. Provide as required by section 01 91 13.

B. All subcontractor and manufacturer startup and proving tests are to be completed and approved prior to conducting the defined Functional Performance Tests.

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C. All associated TAB work and TAB verifications related to a given system shall be completed and approved prior to Functional Performance Testing.

D. All associated Building Management System (BMS) work and BMS point verifications related to a given system shall be completed and approved prior to Functional Performance Testing for related equipment and systems.

E. Development of Test Procedures

1. Plumbing testing procedures shall be based on design sequences of operation and approved equipment and system submittals. The A/E and Sub(s) shall point out to the CxP any specific problems as related to feasibility, safety, equipment, and warranty protection. CxP will observe testing by manufacturers or installing contractors and obtain test reports for inclusion into the Commissioning Final Report.

F. Demonstration, Verification and Validation

The plumbing systems demonstration shall include, at minimum, the following:

1. Electric Water Heaters
2. Fuel Fired Water Heaters
3. Booster Pumps
4. Recirculation Pumps
5. Temperature Mixing Valves
6. Meters

3.4 DEFICIENCIES AND NON-CONFORMANCE

A. Provide as required by section 01 91 13.

3.5 DEFERRED TESTING

A. Provide as required by section 01 91 13.

3.6 TRAINING OF OWNER PERSONNEL

A. Provide training for hardware and major components as specified within Section 01 91 13, 01 79 00, Divisions 22, 23, 26, and in the Commissioning Plan.

B. Coordinate operation and maintenance training activities through the GC.

C. The subcontractor and manufacturers shall provide training. The training sessions provided by the subcontractor shall be customized for this project and reflect all the installed equipment and systems. Training of the materials, components, systems and equipment shall, at the minimum, incorporate the following items:

1. Materials, components, systems, and equipment
2. Safety precautions and procedures

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3. Installation
4. Operational features and functions
5. Operational testing and diagnostics
6. Preventive and predictive maintenance
7. Service: Repair and replacement
8. Operation and Maintenance manual content
9. Testing, adjusting, calibration and balancing.
10. Contractor furnished spare parts and extra materials.
11. Recommended "attic stock" inventory not furnished by contractor.
12. Specialty tool requirements
13. Identification systems
14. Automatic/manual control systems
15. Hazards/Material Safety Data Sheets
16. Cleaning
17. Procurement of replacement parts
18. Warranty reviews including terms and conditions, points of contact, return material procedures, effective date, extended warranty options.
19. Maintenance agreements and similar continuing commitments
20. Reference specification section 01 79 00 for specific requirements.

D. No later than two (2) months following acceptance of equipment and system submittals, the responsible Contractor will submit written training plans to the CxP and Owner for review and approval. There shall be one training plan for each specification section requiring training.

E. Provide Training Plans for all equipment as required in the Division 22 contract specifications.

F. Submit the roster and the completed training plans to the CxP through the GC no later than one (1) week following acceptable completion of the training session.

3.7 OPERATIONS AND MAINTENANCE MANUALS

A. Provide operations and maintenance manuals for hardware and major components as specified within Section 01 78 23, 01 91 13, Divisions 22, 23, 26, and in the Commissioning Plan.

B. Coordinate operation and maintenance submittals through the GC.

C. CxP Review and Approval. Prior to substantial completion, the CxP shall review the operations and maintenance manuals, documentation and redline as-builts for systems that were commissioned to verify compliance with the specifications. The CxP will communicate deficiencies in the manuals to the owner. This work does not supersede the A/E team's review of the operations and maintenance manuals according to the A/E contract.

END OF SECTION 22 08 00

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SECTION 22 09 63

MEDICAL GAS ALARMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Master alarm panels.

1.3 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Product Test Reports: For each alarm panel, for tests performed by a qualified testing agency.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For alarm panels and computer-interface cabinet to include in emergency, operation, and maintenance manuals.

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1.7 QUALITY ASSURANCE

A. Installer Qualifications: Qualify Installers for air, vacuum, and gas piping systems for healthcare facilities according to ASSE Standard #6010 for medical-gas-system installers.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the air, vacuum, and gas piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel for air, vacuum, and gas piping systems for healthcare facilities according to ASSE Standard #6020 for medical-gas-system inspectors and ASSE Standard #6030 for medical-gas-system verifiers.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Gas and Vacuum Systems Monitored:
1. Oxygen, designated "medical oxygen."

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Allied Healthcare Products Inc.
2. Amico Corporation.
3. BeaconMedaes.
4. Ohio Medical .
5. Tri-Tech Medical.

B. Source Limitations: Obtain medical alarm systems and components from single manufacturer.

2.3 GENERAL REQUIREMENTS FOR ALARM PANELS

A. Description: Factory wired with audible and color-coded visible signals to indicate specified functions.

1. Mounting: Recessed installation.
2. Enclosures: Fabricated from minimum 0.047-inch-thick steel or minimum 0.05-inch-thick aluminum, with knockouts for electrical and piping connections.

B. Components: Designed for continuous service and to operate on power supplied from 120 -V ac power source to alarm panels and with connections for low-voltage wiring to remote sensing devices. Include step-down transformers if required.

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C. Dew Point Monitors: Continuous line monitoring, having panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, factory- or field-installed valved bypass, and visual and cancelable audio signal for dryer site and master alarm panels. Alarm signals when pressure dew point rises above 39 deg F at 55 psig.

1. Operation: hygrometer moisture analyzer with sensor probe.

D. Pressure Switches or Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.

1. Low-Pressure Operating Range: 0 to 100 psig.
2. High-Pressure Operating Range: Up to 250 psig.

E. Carbon-Monoxide Monitors: Panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, and factory- or field-installed valved bypass. Alarm signals when carbon-monoxide level rises above 10 ppm.

F. Vacuum Switches or Pressure Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.

1. Vacuum Operating Range: 0 to 30 in. Hg.

2.4 MASTER ALARM PANELS

A. Master Alarm Panels MAP-1: Separate trouble alarm signals and indicators for each system.

1. Standards: Comply with NFPA 99 and UL 544.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Include alarm signals when the following conditions exist:

a. Medical Oxygen:
1) Pressure downstream from main shutoff valve drops below 40 psig or rises above 60 psig.

2.5 COMPUTER-INTERFACE CABINET

A. Description:

1. Wall-mounted, welded-steel, control cabinet with gasketed door.
2. Mounting brackets.
3. Grounding device.
4. White-enamel finish.
5. Factory-installed signal circuit boards.
6. Power transformer.
7. Circuit breaker.

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8. Wiring terminal board, and internal wiring capable of interfacing [**20**] <**Insert number**> alarm signals.

PART 3 - EXECUTION

3.1 INSTALLATION OF ALARM PANELS

A. Install alarm panels in locations required by and according to NFPA 99.

B. Install computer-interface cabinet with connection to alarm panels and facility computer.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 226113 "Compressed-Air Piping for Laboratory and Healthcare Facilities," Section 226213 "Vacuum Piping for Laboratory and Healthcare Facilities," and Section 226313 "Gas Piping for Laboratory and Healthcare Facilities." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to alarm panels allow space for service and maintenance.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment" and according to NFPA 99.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning panels and equipment.

D. Alarm panels will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

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3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 ADJUSTING

A. Adjust initial alarm panel pressure and vacuum set points.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain alarm panels and computer-interface cabinet.

END OF SECTION 22 09 63

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SECTION 22 11 16

DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.

1.3 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

1. All product data from this specification shall be provided as a single submittal for review to engineer of record.

1.4 INFORMATIONAL SUBMITTALS

A. Informational submittals shall be provided from the contractor to the architect/owner for record only. They are not subject to review and approval by the engineer of record.

B. System purging and disinfecting activities report.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Closeout submittals shall be provided from the contractor to the Owner for record only at project close-out. They are not subject to review and approval by the engineer of record.

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PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G. Plastic piping components shall be marked with "NSF-pw."

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type K and ASTM B 88, Type L water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:

1. MSS SP-123.
2. Cast-copper-alloy, hexagonal-stock body.
3. Ball-and-socket, metal-to-metal seating surfaces.
4. Solder-joint or threaded ends.

G. Copper Pressure-Seal-Joint Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Elkhart Products Corporation.
   b. NIBCO INC.
   c. Viega LLC.
   d. Approved Equal.

2. Fittings for NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end and shall conform to ASME B16.51, ICC LC 1002, IAPMO PS 117. Fittings must have Smart Connect Technology or leak detection features.
3. Fittings for NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber, O-ring seal in each end and shall conform to ASME B16.51, ICC LC 1002, IAPMO PS 117. Fittings must have Smart Connect Technology or leak detection features.

H. Appurtenances for Grooved-End Copper Tubing:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anvil International.
    b. Grinnell Mechanical Products.
    c. Shurjoint Piping Products.
    d. Victaulic Company.

2. Bronze Fittings for Grooved-End, Copper Tubing: ASTM B 75 copper tube or ASTM B 584 bronze castings.
3. Mechanical Couplings for Grooved-End Copper Tubing:

    a. Copper-tube dimensions and design similar to AWWA C606.
    b. Ferrous housing sections.
    c. EPDM-rubber gaskets suitable for hot and cold water.
    d. Bolts and nuts.
    e. Minimum Pressure Rating: 300 psig.

2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:

1. AWWA C110/A21.10, ductile or gray iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:

1. AWWA C153/A21.53, ductile iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Push-on-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51.
2. Push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.

E. Standard-Pattern, Push-on-Joint Fittings:

1. AWWA C110/A21.10, ductile or gray iron.
2. Gaskets: AWWA C111/A21.11, rubber.

F. Compact-Pattern, Push-on-Joint Fittings:

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1. AWWA C153/A21.53, ductile iron.
2. Gaskets: AWWA C111/A21.11, rubber.

G. Plain-End, Ductile-Iron Pipe: AWWA C151/A21.51.

H. Appurtenances for Grooved-End, Ductile-Iron Pipe:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Shurjoint Piping Products.
   b. Smith-Cooper International.
   c. Star Pipe Products.
   d. Victaulic Company.

2. Fittings for Grooved-End, Ductile-Iron Pipe: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions that match pipe.
3. Mechanical Couplings for Grooved-End, Ductile-Iron-Piping:

   a. AWWA C606 for ductile-iron-pipe dimensions.
   b. Ferrous housing sections.
   c. EPDM-rubber gaskets suitable for hot and cold water.
   d. Bolts and nuts.

2.4 PEX TUBE AND FITTINGS

A. PEX Distribution System: ASTM F 876 and F877.

B. Fittings for PEX Tube: ASTM F 1960, cold expansion fittings and reinforcing rings matching PEX tube dimensions or PEX Press fittings.

C. Manifold: Multiple-outlet, plastic or corrosion-resistant-metal assembly complying with ASTM F877; with plastic or corrosion-resistant-metal valve for each outlet.

D. Access: Viega ManaBloc 50730 Access Panel, 30" L x 14" W, Plastic, Domestic.

2.5 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:

1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

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E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

F. Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.6 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Watts; a Watts Water Technologies company.
   b. Wilkins.
   c. Zurn Industries, LLC.
   d. Approved Equal.

2. Standard: ASSE 1079.
3. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Watts; a Watts Water Technologies company.
   b. Wilkins.
   c. Zurn Industries, LLC.
   d. Approved Equal.

2. Standard: ASSE 1079.
3. Factory-fabricated, bolted, companion-flange assembly.
4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

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D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.

2. Nonconducting materials for field assembly of companion flanges.
3. Gasket: Neoprene or phenolic.
4. Bolt Sleeves: Phenolic or polyethylene.
5. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Elster Perfection Corporation.
   b. Grinnell Mechanical Products.
   c. Matco-Norca.
   d. Precision Plumbing Products.
   e. Victaulic Company.

2. Standard: IAPMO PS 66.
3. Electroplated steel nipple complying with ASTM F 1545.
4. End Connections: Male threaded or grooved.
5. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance.

E. Install shutoff valve immediately upstream of each dielectric fitting.

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F. Install domestic water piping level and plumb.

G. Rough-in domestic water piping for water-meter installation according to utility company's requirements and include by-pass around meter where required.

H. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

I. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

J. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

K. Install piping to permit valve servicing.

L. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and branch connections.

O. Install PEX piping with loop at each change of direction of more than 90 degrees.

P. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

Q. Install pressure gauges on suction and discharge piping for each plumbing pump and packaged booster pump.

R. Install thermometers on outlet piping from each water heater.

S. Install sleeves for piping penetrations of walls, ceilings, and floors.

T. Install sleeve seals for piping penetrations of concrete walls and slabs.

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Coordinate piping installations and specialty arrangements with Drawings. If Drawings are explicit enough, these requirements may be reduced or omitted.

3.2 JOINT CONSTRUCTION

A. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

1. Mark proper insertion depth prior to making connection.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

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C. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

E. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

F. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

G. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

H. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

I. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

J. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

K. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.3 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

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3.4 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 6 and Larger: Use dielectric flange kits.

3.5 HANGERS AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
4. NPS 2-1/2: 108 inches with 1/2-inch rod.
5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
6. NPS 6: 10 feet with 5/8-inch rod.

E. Install supports for vertical copper tubing every 10 feet.

F. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
2. NPS 1-1/2: 108 inches with 3/8-inch rod.
3. NPS 2: 10 feet with 3/8-inch rod.
4. NPS 2-1/2: 11 feet with 1/2-inch rod.
5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
7. NPS 6: 12 feet with 3/4-inch rod.

G. Install supports for vertical stainless-steel piping every 15 feet.

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H. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold water inlet and hot water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold and hot water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
4. Equipment: Cold and hot water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.7 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

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c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Piping Tests:

a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

1) Press-connect fittings: after installation a “two step test” shall be followed. Pressurize the system with application appropriate test medium, water between 15 and 85 psi, or air/dry nitrogen between .5 and 45 psi. Check the pressure gauge for pressure loss. If the system does not hold pressure, walk the system and check for un-pressed fittings. Should any unpressed fittings be identified following test, ensure the tube is fully inserted into the fitting and properly marked prior to pressing the joint. After appropriate repairs have been made, retest the system per local code and specification requirements, not to exceed 600 psi with water or, 200 psi when using air.

e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.9 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
b. Adjust calibrated balancing valves to flows indicated.

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c. Provide balancing report.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.10 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
b. Fill and isolate system according to either of the following:

1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
d. Repeat procedures if biological examination shows contamination.
e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.11 PIPING SCHEDULE

A. Install piping and materials in locations and applications as permitted by the local plumbing code.

B. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

C. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

D. Under-building-slab, domestic water, building-service piping, NPS 3 and smaller, shall be the following:

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1. Soft copper tube, ASTM B 88, Type K; copper pressure-seal fittings; and pressure-sealed joints.

E. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 and larger, shall be one of the following:

1. Mechanical-joint, ductile-iron pipe; standard-pattern, mechanical-joint fittings; and mechanical joints.
2. Push-on-joint, ductile-iron pipe; standard-pattern, push-on-joint fittings; and gasketed joints.

F. Under-building-slab, domestic water piping, NPS 2 and smaller, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

G. Aboveground domestic water piping, NPS 4 and smaller, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.
3. PEX tube, NPS 2½" and smaller; fittings for PEX tube shall be cold expansion memory type.

H. Aboveground domestic water piping, NPS 6 and larger, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed joints.
2. Hard copper tube, ASTM B 88, Type L; grooved-joint, copper-tube appurtenances; and grooved joints.

3.12 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball valves for piping NPS 2 and smaller. Use ball or gate valves with flanged ends for piping NPS 2-1/2 and larger.
2. Hot-Water Circulation Piping, Balancing Duty: Memory-stop balancing valves or circuit solvers.
3. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

END OF SECTION 22 11 16

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SECTION 22 11 19

DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Balancing valves.
5. Temperature-actuated, water mixing valves.
6. Strainers for domestic water piping.
7. Outlet boxes.
8. Hose stations.
9. Hose bibbs.
10. Wall hydrants.
11. Drain valves.
12. Water-hammer arresters.
13. Flexible connectors.

B. Related Requirements:

1. Section 220500 "Common Work Results for Plumbing."

1.2 DEFINITIONS

A. FKM: A family of fluoroelastomer materials defined by ASTM D1418.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Test and inspection reports.

B. Field quality-control reports.

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1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Domestic water piping specialties intended to convey or dispense water for human consumption are to comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or to be certified in compliance with NSF 61 and NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. Watts.
   c. Zurn Industries, LLC.
   d. Approved Equal.
2. Standard: ASSE 1001.
3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
4. Body: Bronze.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Chrome plated.

B. Hose-Connection Vacuum Breakers

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. Watts.
   c. Woodford Products
   d. Zurn Industries, LLC.

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e. Approved Equal.

2. Standard: ASSE 1011.
3. Body: Bronze, nonremovable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Rough bronze.

C. Pressure Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. Watts.
   c. Zurn Industries, LLC.
   d. Approved Equal.
2. Standard: ASSE 1020.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 5 psig maximum, through middle third of flow range.
5. Accessories:

   a. Valves: Ball type, on inlet and outlet.

2.4 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. Watts.
   c. Zurn Industries, LLC.
   d. Approved Equal.
2. Standard: ASSE 1012.
3. Operation: Continuous-pressure applications.
4. Body: Bronze.
5. End Connections: Union, solder joint.
6. Finish: Rough bronze

B. Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Conbraco Industries, Inc.
   b. Watts.
   c. Zurn Industries, LLC.
   d. Approved Equal.

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2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle third of flow range.
5. Body: Bronze or stainless steel for NPS 2 and smaller; ductile or cast iron with interior lining that complies with AWWA C550 or that is FDA approved or stainless steel for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged or grooved for NPS 2-1/2 and larger.
7. Configuration: Designed for horizontal, straight-through flow unless noted otherwise.
8. Accessories:

    a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.
    b. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
    c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

C. Double-Check, Backflow-Prevention Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Conbraco Industries, Inc.
    b. Watts.
    c. Zurn Industries, LLC.
    d. Approved Equal.

2. Standard: ASSE 1015.
3. Operation: Continuous-pressure applications unless otherwise indicated.
4. Pressure Loss: 5 psig maximum, through middle third of flow range.
5. Body: Bronze or stainless steel for NPS 2 and smaller; ductile or cast iron with interior lining that complies with AWWA C550 or that is FDA approved or stainless steel for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged or grooved for NPS 2-1/2 and larger.
7. Configuration: Designed for horizontal, straight-through flow unless noted otherwise.
8. Accessories:

    a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.
    b. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

D. Beverage-Dispensing-Equipment Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Conbraco Industries, Inc.
    b. Watts.
    c. Zurn Industries, LLC.

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d. Approved Equal.

2. Standard: ASSE 1022.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/4 or NPS 3/8.
5. Body: Stainless steel.
6. End Connections: Threaded or flare.

E. Dual-Check-Valve Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. Watts.
   c. Zurn Industries, LLC.
   d. Approved Equal.
2. Standard: ASSE 1024.
3. Operation: Continuous-pressure applications.
4. Body: Bronze with union inlet.

F. Hose-Connection Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Conbraco Industries, Inc.
   b. Watts.
   c. Woodford Products.
   d. Zurn Industries, LLC.
   e. Approved Equal.

2. Standard: ASSE 1052.
3. Operation: Up to 10-foot head of water back pressure.
4. Inlet Size: NPS 3/4.
5. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
6. Capacity: At least 3-gpm flow.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Conbraco Industries, Inc.
   b. Watts.
   c. Zurn Industries, LLC.
   d. Approved Equal.

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2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig.
4. Body: Bronze for NPS 2 and smaller; bronze or cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
5. Valves for Booster Heater Water Supply: Include integral bypass.
6. End Connections: Threaded or solder for NPS 2 and smaller; flanged or solder for NPS 2-1/2 and NPS 3.

B. Clothes Washer Shutoff Control Valve and Actuator

1. Brass or stainless steel ball valve.
2. End Connections: Male hose connections, NPS 3/4.
3. Pressure Rating: 400 psi at 32 to 150 deg F.
4. Valve Actuator:

    a. Enclosure: Suitable for ambient conditions encountered by application.
    b. Power Supply: 120 V ac
    c. Position Indicator: Standard.

5. Wired Leak Detection System:

    a. Water sensor with minimum 6-foot length of wire.
    b. 120 V ac step-down transformer with cord and plug.
    c. LED operation and leak notification.
    d. Audible alarm.
    e. Power failure or manual disconnection of power causes valves to close.

C. Accessories:

1. Electrical Plug Interrupter: Plugs into standard 120 V ac wall outlet.
2. Step-Down Transformer: 120 V ac to 24 V ac with mounting plate, 12-foot plenum wire to power, and 8-foot plenum wire to sensor.
3. Liquid Level Sensors: Monitor fluid levels in addition to detecting plumbing leaks.

2.6 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Bell & Gossett, Inc.
    b. NIBCO Inc.
    c. Red White Valve Corporation
    d. Watts.
    e. Viega LLC.
    f. Approved Equal.

2. Type: Ball or Y-pattern globe valve with two readout ports and memory-setting indicator.
3. Body: Brass or bronze.

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4. Size: Same as connected piping, but not larger than NPS 2.
5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Automatic Flow Control Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Circuit Solver, Inc.
   b. NIBCO Inc.
   c. Red White Valve Corporation
   d. Viega LLC.
   e. Approved Equal.

2. Flow Regulation: Plus or minus 5 percent over 95 percent of the working range.
3. Pressure Rating: 200 psig.
4. Size: NPS 2 or smaller.
5. Body: Stainless steel or brass.
6. Flow Cartridge: Stainless steel or antiscale polymer.
7. End Connections: Threaded or solder joint.

2.7 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices (MV-1):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Caleffi
   b. Powers.
   c. Watts.
   d. Approved Equal.

2. Standard: ASSE 1070.
3. Pressure Rating: 125 psig.
4. Type: Thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded or union inlets and outlet.
7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.

B. Emergency Fixture, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Bradley Corporation
   b. Guardian Equipment
   c. Haws Corporation.
   d. Speakman.

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e. Approved Equal.

2. Standard: ASSE 1071.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Type: Exposed-mounted thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.

C. Primary, Electronic, Water Mixing Valve Assemblies (TMV-1):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Bradley Corporation
b. Leonard Valve
c. Powers.
d. Watts.
e. Approved Equal.

2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Type: Exposed, electronically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded or solder joint inlets and outlet.
7. Accessories: Manual temperature override control, check stops on hot- and cold-water supplies, and automatic hot- and cold-water shutoff upon inlet supply failure.
8. Valve Finish: Bronze.
9. Digital temperature control and monitoring module.

a. Controls temperature within plus or minus 2 deg F.
b. User programmable at module or through BAS.
c. ASHRAE 188 compliance.
d. Local and remote monitoring.
e. BACNet protocol language(s).
f. 115 V ac, 60 Hz.

2.8 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Conbraco Industries, Inc.
b. Watts.
c. Zurn Industries, LLC.
d. Approved Equal.

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3. Body: Bronze for NPS 2 and smaller; cast iron[with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated for NPS 2-1/2 and larger.
4. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
5. Screen: Stainless steel with round perforations unless otherwise indicated.
6. Drain: Pipe plug or Factory-installed, hose-end drain valve as indicated.

2.9 OUTLET BOXES

A. Clothes Washer Outlet Boxes (SDB-1):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Guy Gray Co.
    b. Precision Plumbing Products.
    c. Souix Chief, LLC.
    d. Approved Equal.

2. Mounting: Recessed. (Fire rated**.** Where required by code)
3. Material and Finish Enameled-steel, epoxy-painted-steel, plastic or stainless steel box and faceplate.
4. Faucet: Combination valved fitting or separate hot- and cold-water valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
5. Drain Outlet Connection: NPS 2.
6. Accessory: Water hammer arresters.
7. Supply Shutoff Fittings: NPS 1/2 gate, globe, or ball valves and NPS 1/2 copper, water tubing.
8. Drain: NPS 2 standpipe and P-trap for direct waste connection to drainage piping.
9. Inlet Hoses: Two 60-inch-long, rubber, household clothes washer inlet hoses with female, garden-hose-thread couplings. Include rubber washers.
10. Drain Hose: One 48-inch-long, rubber, household clothes washer drain hose with hooked end.

B. Icemaker Outlet Boxes (SOB-1):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Guy Gray Co.
    b. Precision Plumbing Products.
    c. Souix Chief, LLC.
    d. Approved Equal.

2. Mounting: Recessed. (Fire rated. Where required by code.)
3. Material and Finish: Enameled-steel, epoxy-painted-steel, plastic or stainless steel box and faceplate.
4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.

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5. Accessory: Water hammer arrestor.
6. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.10 HOSE BIBBS

A. Hose Bibbs (HB-1):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. NIBCO Inc.
    b. Prier Products
    c. Watts.
    d. Woodford Manufacturing
    e. Zurn Industries LLC.
    f. Approved Equal.

2. Approved Equal Standard: ASME A112.18.1 for sediment faucets.
3. Body Material: Bronze.
4. Seat: Bronze, replaceable.
5. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
6. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Pressure Rating: 125 psig.
8. Vacuum Breaker: Integral or field-installation, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
9. Finish: Rough bronze, or chrome or nickel plated.
10. Operation: Wheel handle.
11. Include integral wall flange with each wall mounted hose bibb.

2.11 WALL HYDRANTS

A. Nonfreeze Wall hydrants (WH-1):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Jay R Smith.
    b. Prier Products
    c. Watts.
    d. Woodford Manufacturing
    e. Zurn Industries LLC.
    f. Approved Equal.

2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.

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6. Inlet: NPS 3/4 or NPS 1.
7. Outlet, Concealed: With integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Polished nickel bronze
10. Outlet, Exposed: With integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
11. Nozzle and Wall-Plate Finish: Polished nickel bronze
12. Operating Keys(s): Two with each wall hydrant.

B. Non-freeze, Hot- and Cold-Water Wall Hydrants (WH-2):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Jay R Smith.
    b. Prier Products
    c. Watts.
    d. Woodford Manufacturing
    e. Zurn Industries LLC.
    f. Approved Equal.

2. Standard: ASME A112.21.3M for exposed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rods: Of length required to match wall thickness. Include wall clamps.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet: Concealed.
8. Vacuum Breaker:

    a. Nonremovable, manual-drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
    b. Garden-hose thread complying with ASME B1.20.7 on outlet.

9. Operating Key(s): Two with each wall hydrant.

2.12 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.

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9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Stop-and-Waste Drain Valves:

1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
3. Size: NPS 3/4.
4. Body: Copper alloy or ASTM B62 bronze.
5. Drain: NPS 1/8 side outlet with cap.

2.13 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters (WHA)

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Jay R Smith.
b. Josam.
c. Precision Plumbing Products
d. Zurn Industries LLC.
e. Approved Equal

2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Metal bellows or Piston
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.14 FLEXIBLE CONNECTORS

A. Flexible Connectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Flex-Hose Co. Inc.
b. Flexicraft Industries.
c. Metraflex
d. Approved Equal.

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged copper alloy.

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C. Stainless Steel-Hose Flexible Connectors: Corrugated-stainless steel tubing with stainless steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 (DN 50) and Smaller: Threaded steel-pipe nipple.
3. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

A. Backflow Preventers: Install in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
3. Do not install bypass piping around backflow preventers.

B. Water Regulators: Install with inlet and outlet shutoff valves. Install pressure gauges on inlet and outlet.

C. Balancing Valves: Install in locations where they can easily be adjusted. Set at indicated design flow rates.

D. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet.

E. Y-Pattern Strainers: For water, install on supply side of each water pressure-reducing valve and hot water circulating pump.

F. Outlet Boxes: Install boxes recessed in wall or surface mounted on wall. wall reinforcement between studs.

G. Water-Hammer Arresters: Install in water piping in accordance with PDI-WH 201.

3.2 PIPING CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping specialties adjacent to equipment and machines, allow space for service and maintenance.

NOT FOR BIDDING PURPOSES

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

3.4 CONTROL CONNECTIONS

A. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.5 IDENTIFICATION

A. Plastic Labels for Equipment: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Backflow preventers.
2. Water pressure-reducing valves.
3. Primary, water mixing valves.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.6 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

D. Adjust each reduced-pressure-principle backflow preventer and double-check, backflow-prevention assembly in accordance with manufacturer's written instructions, authorities having jurisdiction and the device's reference standard.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections.

1. Test each reduced-pressure-principle backflow preventer and double-check, backflow-prevention assembly according to authorities having jurisdiction and the device's reference standard.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 22 11 19

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SECTION 22 11 23.13

DOMESTIC-WATER PACKAGED BOOSTER PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Multiplex, variable-speed booster pumps.

B. Related Requirements:

   1. Section 221123 "Domestic Water Pumps" for domestic-water circulation pumps.

1.2 DEFINITIONS

A. PID: Proportional Integral Derivative.

B. VFC: Variable-frequency controller.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Include construction details, material descriptions, and dimensions of individual components and profiles.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For booster pumps.

   1. Include plans, elevations, sections, and details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for booster pumps, accessories, and components, from manufacturer.

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

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2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For booster pumps to include in emergency, operation, and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Retain protective coatings and flange's protective covers during storage.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

B. Seismic Performance: Booster pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

1. The term "withstand" means "the booster pump will remain in place without separation of any parts from the booster pump when subjected to the seismic forces specified and the booster pump will be fully operational after the seismic event."

2.2 MULTIPLEX, VARIABLE-SPEED BOOSTER PUMPS

A. REFERENCE PLUMBING PUMP SPECIFICATION SCHEDULE ON DRAWINGS FOR BASIS OF DESIGN PRODUCT AND MANUFACTURER.

B. ALTERNATE MANUFACTURERS: Subject to compliance with requirements, provide products by one of the following:

1. Armstrong Fluid Technology.
2. Canariis Corporation.
3. Goulds Water Technology; a Xylem brand.
4. Patterson Pump Company; a Gorman-Rupp company.

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5. SyncroFlo, Inc.
6. TIGERFLOW Systems, Inc.

C. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pumps, piping, valves, specialties, and controls, and mounted on base.

D. Pumps, End Suction, Close Coupled:

1. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
2. Casing: Radially split; stainless steel.
3. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
4. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.
5. Seal: Mechanical.
6. Orientation: Mounted horizontally or vertically.
7. Bearings: Water-lubricated bushing type.

E. Motors: Single speed, with pre-greased, permanently shielded, ball-bearings. Select motors that will not overload through full range of pump performance curve.

F. Piping: Stainless-steel pipe and fittings.

G. Valves:

1. Shutoff Valves NPS 2 and Smaller: two-piece, full-port ball valve, in each pump's suction and discharge piping.
2. Shutoff Valves NPS 2-1/2 and Larger: lug-type butterfly valve, in each pump's suction and discharge piping.
3. Check Valves NPS 2 and Smaller: Silent or swing type in each pump's discharge piping.
4. Check Valves NPS 2-1/2 and Larger: Silent type in each pump's discharge piping.
5. Thermal-Relief Valve: Temperature-and-pressure relief type in pump's discharge header piping.

H. Dielectric Fittings: With insulating material to isolate joined dissimilar metals.

I. VFC: Serving each pump in pump array.

1. Touch-screen operator interface.

a. Bidirectional autospeed search.
b. Torque boost.
c. Motor temperature compensation at slow speeds.

1) Panel-mounted operator station.
2) Historical logging information and displays.
3) Digital indicating devices.

d. Control Signal Interface: Electric.
e. Proportional Integral Derivative (PID) control interface.

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2. Bypass Systems:

   a. Bypass Mode: Field-selectable automatic or manual.
   b. Bypass Controller:

3. Instrumentation: Suction and discharge pressure gauges.
4. Lights: Running light or status indicator for each pump.
5. Alarm Signal Device: Sounds alarm when alarm conditions occur.

   a. Time Delay: Controls alarm operation; adjustable from 1 to 300 seconds, with automatic reset.

6. Thermal-bleed cutoff.
7. Low-suction pressure alarm
8. High-suction-pressure alarm and cutout.
9. Low-discharge-pressure alarm and cutout.
10. High-discharge-pressure alarm and cutout.
11. Direct Digital Control (DDC) System for HVAC: Provide auxiliary contacts for interface to BACnet DDC system. DDC systems are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." Include the following:

    a. On-off status of each pump.
    b. Alarm status.

J. Base: Structural steel.

K. Capacities and Characteristics:

1. As indicated on schedule

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in NFPA 70.

2.4 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. ASME Compliance: Comply with ASME B31.9 for piping.

C. UL Compliance for Packaged Pumping Systems:

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1. UL 508, "Industrial Control Equipment."
2. UL 508A, "Industrial Control Panels."
3. UL 778, "Motor-Operated Water Pumps."
4. UL 1995, "Heating and Cooling Equipment."

D. Booster pumps shall be listed and labeled as packaged pumping systems by testing agency acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for booster pumps to verify actual locations of piping connections before booster-pump installation.

3.2 INSTALLATION

A. Booster-Pump Mounting:

1. Install booster pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

B. Support connected domestic-water piping so weight of piping is not supported by booster pumps.

3.3 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Booster-Pump Piping Connections: Connect domestic-water piping to booster pumps. Install suction and discharge pipe equal to or greater than size of system suction and discharge headers.

1. Install shutoff valves on piping connections to booster-pump suction and discharge headers. Install butterfly, or gate valves same size as suction and discharge headers. Comply with requirements for general-duty valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
2. Install flanged or grooved-joint connections on suction and discharge piping at connection to domestic-water piping. Comply with requirements for unions and flanges specified in Section 221116 "Domestic Water Piping."
3. Install valved bypass, same size as and between piping, at connections to booster-pump suction and discharge piping. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."

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4. Install flexible connectors, same size as piping, on piping connections to booster-pump suction and discharge piping. Comply with requirements for flexible connectors specified in Section 221116 "Domestic Water Piping."
5. Where installing piping adjacent to booster pumps, allow space for service and maintenance.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

1. Perform visual and mechanical inspection.
2. Leak Test: After installation, charge booster pump and test for leaks. Repair leaks and retest until no leaks exist.

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3. Operational Test: After electrical circuitry has been energized, start booster pumps to confirm proper motor rotation and booster-pump operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Pumps and controls will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.9 ADJUSTING

A. Adjust booster pumps to function smoothly and lubricate as recommended by manufacturer.

B. Adjust pressure set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting booster pump to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain booster pumps.

END OF SECTION 22 11 23.13

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SECTION 22 11 23.21

INLINE, DOMESTIC-WATER PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. In-line, sealless centrifugal pumps.

B. Related Requirements:

1. Section 221123.13 "Domestic-Water Packaged Booster Pumps" for booster systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction materials, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For inline, domestic-water pumps to include in operation and maintenance manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written instructions for handling.

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PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: UL 778 for motor-operated water pumps.

C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

2.2 IN-LINE, SEALLESS CENTRIFUGAL PUMPS

A. REFERENCE PLUMBING PUMP SPECIFICATION SCHEDULE ON DRAWINGS FOR BASIS OF DESIGN PRODUCT AND MANUFACTURER.

B. ALTERNATE MANUFACTURERS: Subject to compliance with requirements, provide products by one of the following:

1. Flo Fab Inc.
2. GRUNDFOS CBS Inc.
3. Taco Comfort Solutions.
4. WILO USA LLC.

C. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.

D. Capacities and Characteristics:

1. As indicated on schedule.

E. Pump Construction:

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
2. Minimum Working Pressure: 125 psig
3. Maximum Continuous Operating Temperature: 220 deg F.
4. Casing: Bronze or Stainless steel, with threaded or companion-flange connections.
5. Impeller: Plastic or stainless steel.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220500 "Common Work Results for Plumbing."

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1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.4 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Range: 65 to 200 deg F
3. Enclosure: NEMA 250, Type 4X
4. Operation of Pump: On or off.
5. Transformer: Provide if required.
6. Power Requirement: 120 V ac.
7. Settings: Start pump at 110 deg F and stop pump at 120 deg F.

B. Timers: Electric, for control of hot-water circulation pump.

1. Type: Programmable, seven-day clock with manual override on-off switch.
2. Enclosure: NEMA 250, Type 1, suitable for wall mounting.
3. Operation of Pump: On or off.
4. Transformer: Provide if required.
5. Power Requirement: 120 V ac.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for domestic-water-piping system to verify actual locations of piping connections before pump installation.

3.2 INSTALLATION OF PUMPS

A. Comply with HI 1.4.

B. Mount pumps in orientation complying with manufacturer's written instructions.

C. Install continuous-thread hanger rods and vibration isolation of size required to support pump weight.

1. Comply with requirements for vibration isolation devices specified in "Vibration Controls for Plumbing Piping and Equipment." Fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

D. Install thermostats in hot-water return piping.

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E. Install timers at water heater installation.

3.3 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to inline, domestic-water pumps, allow space for service and maintenance.

C. Connect domestic-water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.

D. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for strainers specified in Section 221119 "Domestic Water Piping Specialties." Comply with requirements for valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between temperature controllers and devices.

C. Interlock pump between water heater and hot-water storage tank with water heater burner and time-delay relay.

3.5 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

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3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Inline, domestic-water pump will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Set thermostats, and timers for automatic starting and stopping operation of pumps.
5. Perform the following startup checks for each pump before starting:

   a. Verify bearing lubrication.
   b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   c. Verify that pump is rotating in the correct direction.

6. Prime pump by opening suction valves and closing drains and prepare pump for operation.
7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.8 ADJUSTING

A. Adjust inline, domestic-water pumps to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION 22 11 23.21

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SECTION 22 11 23

NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 100 psig minimum unless otherwise indicated.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Piping specialties.

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2. Corrugated, stainless-steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Dielectric fittings.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

C. Qualification Data: For qualified professional engineer.

D. Welding certificates.

E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas valves pressure regulators and service meters to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating and protect from direct sunlight.

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1.10 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

1.11 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
3. Steel Press-Connect Fittings: CSA LC-4, 125-psig pressure rating.

    a. Press Ends: Unpressed fitting identification feature to the fitting wall.
    b. Pipe Threads: ASME B1.20.1.
    c. Sealing Elements: HNBR.
    d. Tools: Manufacturer's recommended tools, jaws, rings, and actuators.

4. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
5. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

6. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

B. Corrugated, Stainless-Steel Tubing Comply with ANSI/IAS LC 1.

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. FlashShield: a brand of Titeflex.
    b. OmegaFlex, Inc.
    c. Parker Hannifin Corporation.
    d. Approved Equal.

2. Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
3. Coating: PE with flame retardant.

    a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

        1) Flame-Spread Index: 25 of less
        2) Smoke-Developed Index: 50 or less.

4. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
5. Striker Plates: Steel, designed to protect tubing from penetrations.
6. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
7. Operating-Pressure Rating: 5 psig.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches

B. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

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C. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. A.Y. McDonald Mfg. Co.
b. BrassCraft Manufacturing Co.; a Masco company.

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c. Conbraco Industries, Inc.
d. Lyall, R. W. & Company, Inc.
e. Approved Equal.

2. Body: Bronze, complying with ASTM B 584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. A.Y. McDonald Mfg. Co.
b. Lee Brass Company.
c. Approved Equal.

2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.5 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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a. American Meter Company.
b. Fisher Control Valves & Instruments; a brand of Emerson Process Management.
c. Invensys.
d. Itron Gas.
e. Approved Equal.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 100 psig.

C. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Meter Company.
b. Eclipse Innovative Thermal Technologies.
c. Fisher Control Valves & Instruments; a brand of Emerson Process Management.
d. Invensys.
e. Maxitrol Company.
f. Approved Equal.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 2 psig.

D. Appliance Pressure Regulators: Comply with ANSI Z21.18.

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Canadian Meter Company Inc.
    b. Eaton.
    c. Harper Wyman Co.
    d. Maxitrol Company.
    e. Approved Equal.

2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 2 psig.

2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. A.Y. McDonald Mfg. Co.
    b. Watts; a Watts Water Technologies company.
    c. Wilkins.
    d. Zurn Industries, LLC.
    e. Approved Equal.

2. Description:

    a. Standard: ASSE 1079.
    b. Pressure Rating: 125 psig minimum at 180 deg F.
    c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Watts; a Watts Water Technologies company.
    b. Wilkins.
    c. Approved Equal.

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2. Description:

a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 125 psig minimum at 180 deg F.
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.
e. Approved Equal.

2. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

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B. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

C. Install fittings for changes in direction and branch connections.

D. Install pressure gage upstream and downstream from each service regulator.

3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and

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same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

    a. Exception: Tubing passing through partitions or walls does not require striker barriers.

5. Prohibited Locations:

    a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys, or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
    b. Do not install natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gage upstream and downstream from each line regulator.

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W. Install sleeves for piping penetrations of walls, ceilings, and floors.

X. Install sleeve seals for piping penetrations of concrete walls and slabs.

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.5 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

F. Press Joints: Press joints shall be installed with the most current manufacturers installation instructions.

3.7 HANGER AND SUPPORT INSTALLATION

A. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

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1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

B. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod size:

1. NPS 3/8: Maximum span, 48 inches; minimum rod size, 3/8 inch.
2. NPS 1/2: Maximum span, 72 inches; minimum rod size, 3/8 inch.
3. NPS 3/4 and Larger: Maximum span, 96 inches; minimum rod size, 3/8 inch.

3.8 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 LABELING AND IDENTIFYING

A. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

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3.11 OUTDOOR PIPING SCHEDULE

A. Aboveground natural-gas piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints or press joints.

B. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints or press joints. Coat pipe and fittings with protective coating for steel piping.

3.12 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, branch piping NPS 2 and smaller shall be one of the following:

1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
2. Steel pipe with malleable-iron fittings and threaded joints or wrought steel fittings with press joints.

B. Aboveground, distribution piping NPS 2 ½" and larger shall be one of the following:

1. Steel pipe with wrought-steel fittings and welded joints or press joints.

C. Underground, below building, piping shall be the following:

1. Steel pipe with wrought-steel fittings and welded joints or press joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints or press joints. Coat pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints or press joints. Coat underground pipe and fittings with protective exterior coating for steel piping.

3.13 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN OR EQUAL TO 5 PSIG

A. Aboveground, distribution piping shall be the following:

1. Steel pipe with steel welding fittings and welded joints or press joints.

B. Underground, below building, piping shall be the following:

1. Steel pipe with wrought-steel fittings and welded joints or press joints.

C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.

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D. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints or press joints. Coat underground pipe and fittings with protective exterior coating for steel piping.

3.14 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

B. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

C. Valves in branch piping for single appliance shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

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SECTION 22 13 16

SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A Section Includes:

1. Pipe, tube, and fittings.
2. Specialty pipe fittings.
3. Roof Flashing Assemblies.
4. Through-penetration firestop assemblies.
5. Floor Drains
6. Miscellaneous sanitary drainage piping assemblies.
7. Flashing materials.

1.3 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, and be marked with the collective trademark of the Cast Iron Soil Pipe Institute.

B. Comply with NSF/ANSI 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

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PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 COPPER TUBE AND FITTINGS

B. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.

C. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

D. Hard Copper Tube: ASTM B 88, Type L and Type M, water tube, drawn temper.

E. Soft Copper Tube: ASTM B 88, Type L, water tube, annealed temper.

F. Copper Pressure Fittings:

1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

G. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

H. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.3 PVC PIPE FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

C. Adhesive Primer: ASTM F 656.

1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Solvent Cement: ASTM D 2564.

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1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
3. Unshielded, Nonpressure Transition Couplings:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) Dallas Specialty & Mfg. Co.
        2) Fernco Inc.
        3) Froet Industries LLC.
        4) Mission Rubber Company, LLC; a division of MCP Industries.
        5) Plastic Oddities.
        6) Approved Equal.

    b. Standard: ASTM C 1173.
    c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
    d. Sleeve Materials:

        1) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
        2) For Dissimilar Pipes: ASTM D 5926, PVC, or other material compatible with pipe materials being joined.

4. Shielded, Nonpressure Transition Couplings:

    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

        1) Cascade Waterworks Mfg. Co.
        2) Mission Rubber Company, LLC; a division of MCP Industries.

    b. Standard: ASTM C 1460.
    c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

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2.2 CLEANOUTS

A. Exposed Metal Cleanouts:

1. ASME A112.36.2M, Cast-Iron Cleanouts:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Jay R. Smith Mfg. Co.
2) Josam Company.
3) Charlotte Pipe and Foundry
4) Tyler Pipe; a subsidiary of McWane Inc.
5) Zurn Industries, LLC.
6) Approved Equal.

B. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Jay R. Smith Mfg. Co.
b. Josam Company.
c. Charlotte Pipe and Foundry
d. Tyler Pipe; a subsidiary of McWane Inc.
e. Zurn Industries, LLC.
f. Approved Equal.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: as required to match connected piping.
5. Closure: Countersunk or raised-head brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
8. Wall Access: Round stainless-steel wall-installation frame and cover.

2.3 FLOOR DRAINS:

A. Description: REFERENCE PLUMBING DRAIN SPECIFICATION SCHEDULE ON DRAWINGS FOR BASIS OF DESIGN FLOOR DRAINS, FLOOR SINKS, TRENCH AND TROUGH DRAINS.

B. ALTERNATE MANUFACTURERS: Subject to compliance with requirements, provide products by one of the following for each scheduled drain type:

1. Floor Drains:

a. Jay R Smith Mfg. Company
b. Josam Company
c. Watts

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d. Zurn Industries, LLC

2. Floor Sinks:

a. Jay R Smith Mfg. Company
b. Josam Company
c. Watts
d. Zurn Industries, LLC

3. Trench Drains:

a. Eagle Group, Food Service Division

4. Trough Drains:

a. H-M Company

2.4 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Acorn Engineering Company.
b. Thaler Metal Industries Ltd.
c. Zurn Industries, LLC.
d. Approved Equal.

2. Description: Manufactured assembly made of 4.0-lb/sq. ft., 0.0625-inch thick, lead flashing collar and skirt extending at least 10 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.

a. Open-Top Vent Cap: Without cap.
b. Low-Silhouette Vent Cap: With vandal-proof vent cap.
c. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.5 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. ProSet Systems Inc.

2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected soil, waste, or vent stack.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.

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5. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
6. Special Coating: Corrosion resistant on interior of fittings.

2.6 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
2. Size: Same as connected waste piping.

B. Floor-Drain, Trap-Seal Primer Fittings:

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

C. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

D. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

E. Stack Flashing Fittings:

1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

F. Vent Caps:

1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

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2.7 FLASHING MATERIALS

A. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.

B. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

C. Fasteners: Metal compatible with material and substrate being fastened.

D. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

E. Solder: ASTM B 32, lead-free alloy.

F. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drainpipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and

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reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

J. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

K. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 2 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Sanitary Drainage Piping: 1 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

L. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

M. Install above ground PVC piping according to ASTM D 2665. PVC piping shall not be installed in return air plenums.

N. Install underground PVC piping according to ASTM D 2321.

O. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

P. Install sleeves for piping penetrations of walls, ceilings, and floors.

Q. Install sleeve seals for piping penetrations of concrete walls and slabs.

R. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.2 JOINT CONSTRUCTION

A. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

B. Plastic, Non-pressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.3 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in OD's.

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2. In Drainage Piping: Unshielded, nonpressure transition couplings.
3. In Aboveground Force Main Piping: Fitting-type transition couplings.
4. In Underground Force Main Piping:

    a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
    b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or unions.
3. Dielectric Fittings for NPS 2-1/2 and larger: Use dielectric nipples.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
3. Vertical Piping: MSS Type 8 or Type 42, clamps.
4. Install individual, straight, horizontal piping runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
6. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support horizontal piping and tubing within 12 inches of each fitting**,** valve and coupling.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4: 72 inches with 3/8-inch rod.
2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
3. NPS 2-1/2: 108 inches with 1/2-inch rod.
4. NPS 3 and NPS 5: 10 feet with 1/2-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

G. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.

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2. NPS 3: 48 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.

H. Supports for vertical PVC piping every 48 inches.

I. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

J. Install rigid bracing on piping 4" and larger where a pipe fitting in that piping changes the flow of direction greater than 45 degrees to resist movement of the upstream pipe in the direction of pipe flow. Anchorage shall be installed to restrain drainage piping from axial movement. For pipe sizes greater than 4", restraints shall be provided at all changes of direction and at all changes in diameter greater than two pipe sizes. Braces, blocks or other suitable methods as recommended by the coupling manufacturer shall be utilized.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.6 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

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3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.8 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

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3.9 PIPING SCHEDULE

A. Install piping and materials in locations and applications as permitted by the local plumbing code.

B. Aboveground, sanitary waste and vent piping shall be the following:

1. Copper DWV tube, copper drainage fittings, and soldered joints above kitchen and food preparation areas.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

C. Aboveground, sanitary waste and vent piping serving commercial kitchens systems to the point of connection at the standard sanitary waste and vent piping systems shall be the following:

1. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints
2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

D. Underground, soil, waste, and vent piping serving commercial kitchens systems to the point of connection at the standard sanitary waste and vent piping systems shall be the following:

1. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints
2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

E. Underground, soil, waste, and vent piping shall be any of the following:

1. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints
2. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.

3.10 INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.

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3. Install floor-drain flashing collar or flange and flash accordingly so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

E. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

F. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system. Center indirect waste piping directly over drain receiving waste and include required air gap and 90° turn down elbow at discharge location.

G. Install sleeve flashing device with each riser and stack passing through floors.

H. Install vent caps on each vent pipe passing through roof.

I. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

J. Install wood-blocking reinforcement for wall-mounting-type specialties.

K. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.11 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, floor drains, and specialties passing through or embedded in floors and roofs.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Floor Drain and Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around drain or specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

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E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings.

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

END OF SECTION 22 13 16

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SECTION 22 14 14

STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipe, tube, and fittings.
2. Specialty pipe fittings.
3. Encasement for underground metal piping.
4. Cleanouts
5. Roof Drains
6. Through-penetration firestop assemblies
7. Flashing materials.

1.3 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Storm Drainage Piping: 10-foot head of water.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1. All product data from this specification shall be provided as a single submittal for review to engineer of record.

1.5 INFORMATIONAL SUBMITTALS

A. Informational submittals shall be provided from the contractor to the architect/owner for record only. They are not subject to review and approval by the engineer of record.

NOT FOR BIDDING PURPOSES

1.6 CLOSEOUT SUBMITTALS

A. Closeout submittals shall be provided from the contractor to the Owner for record only at project close-out. They are not subject to review and approval by the engineer of record.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

C. Adhesive Primer: ASTM F 656.

1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Solvent Cement: ASTM D 2564.

1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 CLEANOUTS

A. Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Jay R. Smith Mfg. Co.
b. Josam Company.
c. Charlotte Pipe and Foundry
d. Sioux Chief Manufacturing Company, Inc.
e. Tyler Pipe; a subsidiary of McWane Inc.
f. Zurn Industries, LLC.

NOT FOR BIDDING PURPOSES

g. Approved Equal.

2. Standard: ASME A112.36.2M, for cast-iron soil pipe with cast-iron ferrule or heavy-duty, adjustable housing cleanouts.
3. Size: Same as connected branch.
4. Type: Cast-iron soil pipe with cast-iron ferrule or Heavy-duty, adjustable housing.
5. Body or Ferrule Material: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: As required.
8. Closure: Brass plug with straight threads and gasket.
9. Adjustable Housing Material: Cast iron.
10. Frame and Cover Material and Finish: Rough bronze.
11. Frame and Cover Shape: Round.
12. Top-Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

B. Test Tees:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Jay R. Smith Mfg. Co.
b. Josam Company.
c. Charlotte Pipe and Foundry
d. Tyler Pipe; a subsidiary of McWane Inc.
e. Zurn Industries, LLC.
f. Approved Equal.

2. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301, for cleanout test tees.
3. Size: Same as connected drainage piping.
4. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or hubless, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure Plug: Countersunk or raised head, brass.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Jay R. Smith Mfg. Co.
b. Josam Company.
c. Charlotte Pipe and Foundry
d. Tyler Pipe; a subsidiary of McWane Inc.
e. Zurn Industries, LLC.
f. Approved equal.

2. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
3. Size: Same as connected drainage piping.
4. Body Material: As required to match connected piping.

NOT FOR BIDDING PURPOSES

5. Closure: Countersunk or raised-head plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
8. Wall Access: Round stainless-steel wall-installation frame and cover.

2.4 ROOF DRAINS:

A. Description: REFERENCE PLUMBING DRAIN SPECIFICATION SCHEDULE ON DRAWINGS FOR BASIS OF DESIGN ROOF AND OVERFLOW DRAINS.

B. ALTERNATE MANUFACTURERS: Subject to compliance with requirements, provide products by one of the following for each scheduled drain type:

1. Roof Drains / Overflow Drains:
   a. Jay R Smith Mfg. Company
   b. Josam Company
   c. Watts
   d. Zurn Industries, LLC

2.5 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. ProSet Systems Inc.
   b. Approved Equal.

2. Standard: ASTM E 814, for through-penetration firestop assemblies.
3. Certification and Listing: Testing agency acceptable to authorities having jurisdiction for through-penetration firestop assemblies.
4. Size: Same as connected pipe.
5. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
6. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
7. Special Coating: Corrosion resistant on interior of fittings.

2.6 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M,12 oz./sq. ft.

B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.

NOT FOR BIDDING PURPOSES

C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

D. Fasteners: Metal compatible with material and substrate being fastened.

E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

F. Solder: ASTM B 32, lead-free alloy.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

J. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

K. Install storm drainage piping at the following minimum slopes unless otherwise indicated:

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1. Building Storm Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Storm-Drainage Piping: 1 percent downward in direction of flow.

L. Install aboveground PVC piping according to ASTM D 2665. PVC piping shall not be installed in return air plenums.

M. Install underground PVC piping according to ASTM D 2321.

N. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.

O. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

P. Install sleeves for piping penetrations of walls, ceilings, and floors.

Q. Install sleeve seals for piping penetrations of concrete walls and slabs.

R. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.2 JOINT CONSTRUCTION

A. Plastic, Nonpressure-Piping, Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.3 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
3. Vertical Piping: MSS Type 8 or Type 42, clamps.
4. Individual, Straight, Horizontal Piping Runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
6. Base of Vertical Piping: MSS Type 52, spring hangers.

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B. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

E. Install supports for vertical copper tubing every 10 feet.

F. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
2. NPS 3: 48 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 48 inches with 3/4-inch rod.

G. Install supports for vertical PVC piping every 48 inches.

H. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

I. Install rigid bracing on piping 4" and larger where a pipe fitting in that piping changes the flow of direction greater than 45 degrees to resist movement of the upstream pipe in the direction of pipe flow. Anchorage shall be installed to restrain drainage piping from axial movement. For pipe sizes greater than 4", restraints shall be provided at all changes of direction and at all changes in diameter greater than two pipe sizes. Braces, blocks or other suitable methods as recommended by the coupling manufacturer shall be utilized.

3.4 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect storm drainage piping to roof drains and storm drainage specialties.

1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.

C. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.5 IDENTIFICATION

A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.6 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

NOT FOR BIDDING PURPOSES

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.7 PIPING SCHEDULE

A. Install piping and Materials in locations and applications as permitted by the local plumbing code.

B. Aboveground storm drainage piping shall be any of the following:

1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

C. Underground storm drainage piping shall be any of the following:

1. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

3.8 INSTALLATION

A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.

1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
2. Install expansion joints, if indicated, in roof drain outlets.
3. Position roof drains for easy access and maintenance.

B. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:

1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate cleanouts at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install test tees in vertical conductors and near floor.

F. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

G. Install through-penetration firestop assemblies in plastic conductors at concrete floor penetrations.

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H. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.9 FLASHING INSTALLATION

A. Install sheet flashing on pipes, sleeves, drains, and specialties passing through or embedded in floors and roofs.

1. Pipe Flashing: Sleeve type, matching the pipe size, with a minimum length of 10 inches and with skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

B. Set flashing on floors and roofs in solid coating of bituminous cement.

C. Secure flashing into sleeve and specialty clamping ring or device.

D. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.10 PROTECTION

A. Protect drains during the remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 14 14

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SECTION 22 14 29

SUMP PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Oil-sensing sump pumps and controllers.

1.2 ACTION SUBMITTALS

A. Product Data:
1. Oil-sensing sump pumps and controllers.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps and controls.

1. Indicate actual installed items by marking submittals with an arrow or box.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with manufacturer's written instructions for handling.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of sump pump from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

NOT FOR BIDDING PURPOSES

2.3 OIL-SENSING SUMP PUMPS AND CONTROLLERS

A. REFERENCE PLUMBING PUMP SPECIFICATION SCHEDULE ON DRAWINGS FOR BASIS OF DESIGN PRODUCT AND MANUFACTURER.

B. ALTERNATE MANUFACTURERS: Subject to compliance with requirements, provide products by one of the following:

a. Bell & Gossett. Company
b. EBARA Pumps Corporation
c. Stancor, Inc.
d. Zoeller Pump Company

C. Description:
1. Factory-assembled and -tested sump-pump unit. ASME A17.1 compliant.
2. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 14.1-14.2 and HI 14.3.
3. Pump Casing: Cast iron or Stainless steel with strainer inlet; legs that elevate pump to permit flow into impeller; and vertical discharge for piping connection.
4. Capacities and Characteristics:
   a. As indicated on schedule.
   b. Industrial-grade switch(es) with internal relay and Type 304 stainless steel sensor probes.
   c. Liquid/oil sensor that differentiates and indicates the presence of oil and/or water under high-water conditions.
   d. Alarm and control Panel:
      1) High-oil-level alarm.
      2) High-water-level alarm.
      3) Audible and visual alarms for each alarm condition.
      4) Dry contacts for remote monitoring of oil, water, and high liquid conditions.
      5) Simplex or Duplex
      6) HOA switches.
      7) Green pump run light; power on light.
      8) Pump circuit breaker(s).

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220500 "Common Work Results for Plumbing."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Motors for submersible pumps are to be hermetically sealed.

NOT FOR BIDDING PURPOSES

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation and filling are specified in Section 312000 "Earth Moving."

3.2 EXAMINATION

A. Examine roughing-in for plumbing piping to verify actual locations of storm drainage piping connections before sump-pump installation.

3.3 INSTALLATION

A. Pump Installation Standards: Comply with HI 14.4 for installation of sump pumps.

B. Equipment Mounting:
1. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

C. Wiring Method: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.4 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 221414 "Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.

3.6 ADJUSTING

A. Adjust pumps to function smoothly and lubricate as recommended by manufacturer.

B. Adjust control set points.

NOT FOR BIDDING PURPOSES

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test, inspect, and adjust components, assemblies, and equipment installations, including connections.

B. Tests and inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Pumps and controls will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION 22 14 29

NOT FOR BIDDING PURPOSES

SECTION 22 34 00

FUEL-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Gas-fired, tankless, domestic-water heaters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Equipment room drawing or BIM model, drawn to scale, on which the items described in this Section are shown and coordinated with all building trades.

B. Product Certificates: For each type of gas-fired, tankless domestic-water heater.

C. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuel-fired, domestic-water heaters to include in emergency, operation, and maintenance manuals.

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1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including storage tank and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

a. Gas-Fired, Tankless, Domestic-Water Heaters:

1) Heat Exchanger: Five years.
2) Controls and Other Components: Three years.

b. Expansion Tanks: Five years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. Seismic Performance: Commercial domestic-water heaters shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

C. ASHRAE/IES Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IES 90.1.

D. ASME Compliance:

1. Where ASME-code construction is indicated, fabricate and label, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

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E. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

2.2 GAS-FIRED, TANKLESS, DOMESTIC-WATER HEATERS

A. REFERENCE PLUMBING EQUIPMENT SPECIFICATION SCHEDULE ON DRAWINGS FOR BASIS OF DESIGN PRODUCT AND MANUFACTURER.

B. ALTERNATE MANUFACTURERS: Subject to compliance with requirements, provide products by one of the following:

1. AERCO Inc.
2. Intellihot.
3. Laars Heating System Company
4. PVI.

C. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.

D. Standard: ANSI Z21.10.3/CSA 4.3 for gas-fired, instantaneous, domestic-water heaters for indoor application.

E. Construction: Copper piping or tubing complying with NSF 61 and NSF 372 barrier materials for potable water, without storage capacity.

1. Tappings: ASME B1.20.1 pipe thread.
2. Pressure Rating: 150 psig (1035 kPa).
3. Heat Exchanger: Stainless steel.
4. Insulation: Comply with ASHRAE/IES 90.1.
5. Jacket: Metal, with enameled finish, or plastic.
6. Burner: For use with tankless, domestic-water heaters and natural-gas fuel..
7. Automatic Ignition: Manufacturer's proprietary system for automatic, gas ignition.
8. Temperature Control: Adjustable thermostat.

F. Capacity and Characteristics:

1. As indicated on schedule.

2.3 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Expansion Tanks:

1. REFERENCE PLUMBING EXPANSION TANK SPECIFICATION SCHEDULE ON DRAWINGS FOR BASIS OF DESIGN PRODUCT AND MANUFACTURER.
2. ALTERNATE MANUFACTURERS: Subject to compliance with requirements, provide products by one of the following:

a. AA Tanks.

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b. Amtrol Inc.
c. Watts
d. Wessels Company.

3. Source Limitations: Obtain domestic water expansion tanks from single source from single manufacturer.
4. Description: ASME construction Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
5. Construction:

a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
c. Air-Charging Valve: Factory installed.

6. Capacity and Characteristics:

a. As indicated on schedule:

B. Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with ASHRAE/IES 90.1.

C. Heat-Trap Fittings: ASHRAE 90.2.

D. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."

1. Comply with requirements for balancing valves specified in Section 221119 "Domestic Water Piping Specialties."

E. Gas Shutoff Valves: ANSI Z21.15/CSA 9.1, manually operated. Furnish for installation in piping.

F. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Include 2-psig pressure rating as required to match gas supply.

G. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valves with sensing element that extends into storage tank.

1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4.

H. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

NOT FOR BIDDING PURPOSES

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled domestic-water heaters specified to be ASME-code construction, in accordance with ASME Boiler and Pressure Vessel Code.

B. Domestic-water heaters will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF DOMESTIC-WATER HEATER

A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
2. Maintain manufacturer's recommended clearances.
3. Arrange units so controls and devices that require servicing are accessible.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Install anchor bolts to elevations required for proper attachment to supported equipment.
8. Anchor domestic-water heaters to substrate.

B. Tankless, Domestic-Water Heater Mounting:

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Anchor domestic-water heaters to substrate.

C. Install domestic-water heaters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."

NOT FOR BIDDING PURPOSES

D. Install gas-fired, domestic-water heaters in accordance with NFPA 54.

1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in Section 231123 "Natural-Gas Piping".

E. Install oil-fired, domestic-water heaters in accordance with NFPA 31.

1. Install shutoff valves on fuel-oil supply piping to oil-fired water-heater burners without shutoff valves. Comply with requirements for shutoff valves specified in Section 231113 "Facility Fuel-Oil Piping."

F. Install commercial domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" and Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

G. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

H. Install combination temperature-and-pressure relief valves in water piping for domestic-water heaters without storage. Extend domestic-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

I. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

J. Install thermometer on outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."

K. Assemble and install inlet and outlet piping manifold kits for multiple domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each domestic-water heater outlet. Comply with requirements for valves specified in Section 220523 "General-Duty Valves for Plumbing Piping" and comply with requirements for thermometers specified in Section 220500 "Common Work Results for Plumbing."

NOT FOR BIDDING PURPOSES

L. Install piping-type heat traps on inlet and outlet piping of domestic-water heater storage tanks without integral or fitting-type heat traps.

M. Fill domestic-water heaters with water.

N. Charge domestic-water expansion tanks with air to required system pressure.

O. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water shall contain less than 0.25 percent of lead by weight.

3.2 PIPING CONNECTIONS

A. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."

B. Comply with requirements for fuel-oil piping specified in Section 231113 "Facility Fuel-Oil Piping."

C. Comply with requirements for gas piping specified in Section 231123 "Natural-Gas Piping".

D. Drawings indicate general arrangement of piping, fittings, and specialties.

E. Where installing piping adjacent to fuel-fired, domestic-water heaters allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Testing Agency:

1. Owner will engage a qualified testing agency to perform tests and inspections.
2. Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

NOT FOR BIDDING PURPOSES

2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Domestic-water heaters will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain gas-fired domestic-water heaters. Training shall be a minimum of two hour(s).

END OF SECTION 22 34 00

NOT FOR BIDDING PURPOSES

SECTION 22 41 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. All product data from this specification shall be provided as a single submittal for review to engineer of record.
2. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
3. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Informational submittals shall be provided from the contractor to the architect/owner for record only. They are not subject to review and approval by the engineer of record.

B. Coordination Drawings: Counter cutout templates for mounting of counter-mounted plumbing fixtures.

1.4 CLOSEOUT SUBMITTALS

A. Closeout submittals shall be provided from the contractor to the Owner for record only at project close-out. They are not subject to review and approval by the engineer of record.

B. Operation and Maintenance Data: For plumbing fixtures and faucets to include in operation and maintenance manuals.

NOT FOR BIDDING PURPOSES

PART 2 - PRODUCTS

2.1 REFERENCE PLUMBING FIXTURE SPECIFICATION SCHEDULES ON DRAWINGS FOR BASIS OF DESIGN PLUMBING FIXTURES AND TRIM.

2.2 ALTERNATE MANUFACTURERS: Subject to compliance with requirements, provide products by one of the following for each scheduled fixture type:

A. Water Closets:

1. American Standard Companies
2. Kohler Company
3. Sloan Valve Company
4. Zurn Industries, LLC

B. Flushometers:

1. American Standard Companies
2. Moen Inc.
3. Sloan Valve Company
4. Zurn Industries, LLC

C. Lavatories:

1. American Standard Companies
2. Kohler Company
3. Zurn Industries, LLC

D. Lavatory Faucets (Manual operation):

1. American Standard Companies
2. Kohler Company
3. Moen Inc.
4. Zurn Industries LLC

E. Lavatory Faucets (Sensor Operation):

1. American Standard Companies
2. Kohler Company
3. Moen Inc.
4. Sloan Valve Company
5. Zurn Industries, LLC

F. Fixture Supports:

1. Jay R Smith Mfg. Company
2. Josam Company
3. Watts
4. Zurn Industries, LLC

NOT FOR BIDDING PURPOSES

G. Counter Mounted Sinks:

1. Elkay Manufacturing Company
2. Just Manufacturing

H. Sink Faucets:

1. American Standard Companies
2. Chicago Faucets
3. Kohler Company
4. Moen Inc.
5. Speakman
6. T & S Brass
7. Zurn Industries, LLC

I. Shower Mixing Valves and Trim:

1. American Standard Companies
2. Delta Faucets
3. Kohler Company
4. Moen Inc.
5. Zurn Industries, LLC

J. Bathtubs and Trim:
1. Invacare

K. Clinic Service Sinks:

1. American Standard Companies
2. Kohler Company
3. Zurn Industries, LLC

L. Clinic Service Sink Faucets:
1. Chicago Faucets
2. Sloan Valve Company
3. T & S Brass
4. Zurn Industries, LLC

M. Electric Water Coolers:

1. Elkay Manufacturing Company
2. Haws Corporation
3. Oasis International
4. Sunroc Corporation

N. Mop receptors:

1. E.L. Mustee & Sons, Inc.
2. Fiat Products
3. Florestone Inc.
4. Zurn Industries, LLC

NOT FOR BIDDING PURPOSES

O. Mop Receptor Faucets:

1. Chicago Faucets
2. Fiat Products
3. Speakman
4. T & S Brass
5. Zurn Industries, LLC

P. Salon Sinks and Trim:

1. Accessible Systems, Inc.

Q. Toilet Seats:

1. American Standard Companies
2. Bemis Mfg, Inc.
3. Kohler Company
4. Sloan Valve Company
5. Zurn Industries, LLC

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing-fixture installation.

B. Examine walls, floors, cabinets, and counters for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install plumbing fixtures level and plumb in accordance with roughing-in drawings.

B. Install floor-mounted water closets on closet flange attachments to drainage piping.

C. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to INCC/ANSI 117.1.

D. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

E. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.

F. Install flush valves actuators in locations that are easy for people with disabilities to reach.

NOT FOR BIDDING PURPOSES

G. Install fresh batteries in battery-battered, electronic-sensor faucet and flush valve mechanisms.

H. Install counter-mounting fixtures in and attached to casework.

I. Install pedestal lavatories on pedestals and secured to wood blocking in wall.

J. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball or gate valves if supply stops are not specified with fixture.

K. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

L. Install toilet seats on water closets.

M. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

N. Install shower flow-control fittings with specified maximum flow rates in shower arms.

O. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes unless otherwise indicated.

P. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible fixtures.

Q. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings.

R. Seal joints between plumbing fixtures, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

3.4 ADJUSTING

A. Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

C. Adjust all infrared sensors for proper operation and duration as required.

NOT FOR BIDDING PURPOSES

3.5 CLEANING AND PROTECTION

A. After completing installation of plumbing fixtures, inspect and repair damaged finishes.

B. Clean plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed plumbing fixtures and fittings.

D. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 41 00

NOT FOR BIDDING PURPOSES

SECTION 22 63 13

GAS PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Joining materials.
3. Zone valve box assemblies.
4. Ball valves.
5. Check valves.
6. Gas safety valves.
7. Pressure regulators.
8. Gas-service connectors.

B. Owner-Furnished Material:

1. Turn Key Bulk medical gas storage tanks.
2. Owner will furnish gases for medical gas concentration testing specified in this Section.

C. Related Requirements:

1. Section 220963 "Medical Gas Alarms" for combined medical air, vacuum, and gas alarms.

1.2 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. Medical gas piping systems include medical oxygen healthcare facility patient care.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

NOT FOR BIDDING PURPOSES

B. Material Certificates: Signed by Installer, certifying that medical gas piping materials comply with requirements in NFPA 99 for positive-pressure medical gas systems.

C. Brazing certificates.

D. Field quality-control reports.

E. Source Quality-Control Reports:

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For medical gas piping specialties to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Quick-Coupler Service Connections: Furnish complete noninterchangeable medical gas-pressure outlets and suction inlets.

a. Medical Oxygen: Equal to 20 percent of quantity installed, but no fewer than 10 units.

2. D.I.S.S. Service Connections: Furnish complete medical gas pressure outlets and suction inlets complying with CGA V-5.

a. Medical Oxygen D.I.S.S. No. 1240: Equal to 20 percent of quantity installed, but no fewer than 10 units.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Medical Gas Piping Systems for Healthcare Facilities: In accordance with ASSE Standard #6010 and NFPA 99 for medical-gas-system installers.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the medical gas piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel in accordance with ASSE Standard #6020 and NFPA 99 for medical-gas-system inspectors and ASSE Standard #6030 for medical-gas-system verifiers.

NOT FOR BIDDING PURPOSES

C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications," or AWS B2.2/B2.2M.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Medical oxygen operating at 50 to 55 psig (345 to 380 kPa).

2.2 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 99.

2.3 PIPES, TUBES, AND FITTINGS

A. For all medical gases, all positive-pressure medical gas piping, tubing, and fittings shall have been manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.

1. Each length of tubing shall be delivered plugged or capped by the manufacturer and kept sealed until prepared for installation.
2. Fittings and other components shall be delivered manufacturer sealed and labeled, and kept sealed until prepared for installation.

B. Copper Medical and Laboratory Gas Tube: ASTM B819 Type L, seamless, drawn temper. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in blue for Type L tube.

C. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type.

D. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

E. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.

1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, full-face type.
2. Flange Bolts and Nuts: ASME B18.2.1 carbon steel.

2.4 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys.

B. Threaded-Joint Tape: PTFE.

NOT FOR BIDDING PURPOSES

2.5 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged in accordance with CGA G-4.1 for oxygen service.

B. Zone Valve Box Assemblies: Box with medical gas valves, tube extensions, and gauges.

1. Steel Zone Valve Box with Aluminum Cover:

a. Approved manufacturers

1) Amico
2) Beacon Medeas
3) Pattons Medical
4) Ohio Medical
5) Silbermann

b. Description: Formed-steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gauges and in sizes required to permit manual operation of valves. Tubing, valves, and gauges may be incorporated in zone valve boxes for medical oxygen

1) Interior Finish: Factory-applied white enamel.
2) Cover Plate: Aluminum with frangible or removable windows.
3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, in accordance with NFPA 99.

2. Positive-pressure medical gas valves, for all medical gas types, shall be manufacturer cleaned, degreased, purged, sealed and bagged for oxygen service, in accordance with CGA G-4.1.

a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

3. Steel Zone Valve Box with Stainless Steel Cover:

a. Approved manufacturers

1) Amico
2) Beacon Medeas
3) Pattons Medical
4) Ohio Medical
5) Silbermann

b. Description: Formed-steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gauges and in sizes required to permit manual operation of valves. Tubing, valves, and gauges may be incorporated in zone valve boxes for medical oxygen.

NOT FOR BIDDING PURPOSES

1) Interior Finish: Factory-applied white enamel.
2) Cover Plate: Stainless steel with frangible or removable windows.
3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, in accordance with NFPA 99.

c. Positive-pressure gas valves, for all medical gas types, shall be manufacturer cleaned, degreased, purged, sealed and bagged for oxygen service, in accordance with CGA G-4.1.

1) Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

C. Ball Valves:

1. Approved manufacturers:

a. Amico
b. US Valve
c. Apollo Valve
d. Pattons Medical
e. Ohio Medical

2. Standard: MSS SP-110.
3. Description: Three-piece body, brass, or bronze.
4. Pressure Rating: 300 psig minimum.
5. Ball: Full-port, chrome-plated brass.
6. Seats: PTFE or TFE.
7. Handle: Lever type with locking device.
8. Stem: Blowout proof with PTFE or TFE seal.
9. Ends: Manufacturer-installed ASTM B819, copper-tube extensions and manufacturer-installed ASTM B819, copper-tube extensions with pressure gauge on one copper-tube extension.
10. Positive-pressure gas valves, for all medical gas types, shall be manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.

a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

D. Check Valves:

1. Approved manufacturers:

a. Amico
b. US Valve
c. Apollo Valve
d. Pattons Medical
e. Ohio Medical

2. Description: In-line pattern, bronze.
3. Pressure Rating: 300 psig (2070 kPa) minimum.

NOT FOR BIDDING PURPOSES

4. Operation: Spring loaded.
5. Ends: Manufacturer-installed ASTM B819, copper-tube extensions.
6. Positive-pressure gas valves, for all gas types, shall be manufacturer cleaned, degreased, purged, sealed and bagged for oxygen service, in accordance with CGA G-4.1.

    a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

E. Emergency Oxygen Connections: Low-pressure oxygen inlet assembly for connection to building oxygen piping systems.

1. Approved manufacturers:

    a. Amico
    b. Beacon Medaes
    c. Pattons Medical
    d. Ohio Medical

2. Enclosure: Weatherproof hinged locking cover with caption similar to "Emergency Low-Pressure Gaseous Oxygen Inlet."
3. Inlet: Manufacturer-installed, NPS 3/4 (DN 20), ASTM B819, copper tubing with NPS 3/4(DN 20) minimum ball valve.
4. Safety Valve: Bronze-body pressure-relief valve set at 75 or 80 psig (520 or 550 kPa).
5. Instrumentation: Pressure gauge.
6. Positive-pressure gas valves, for all gas types, shall be manufacturer cleaned, degreased, purged, sealed and bagged for oxygen service, in accordance with CGA G-4.1.

    a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

F. Gas Safety Valves:

1. Approved manufacturers:

    a. Amico
    b. Pattons Medical

2. Bronze body.
3. ASME-construction, poppet, pressure-relief type.
4. Valve to be constructed of non-combustible, oxygen service compatible materials.
5. Settings to match system requirements.
6. Positive-pressure gas valves, for all gas types, shall be manufacturer cleaned, degreased, purged, sealed, and bagged for oxygen service, in accordance with CGA G-4.1.

    a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

G. Pressure Regulators:

1. Bronze body and trim.

NOT FOR BIDDING PURPOSES

2. Regulators to be constructed of non-combustible, oxygen service compatible materials.
3. Settings to match system requirements.
4. Spring-loaded, diaphragm-operated, relieving type.
5. Manual pressure-setting adjustment.
6. Rated for 250-psig (1725-kPa) minimum inlet pressure.
7. Capable of controlling delivered gas pressure within 0.5 psig for each 10-psig (5.0 kPa for each 100-kPa) inlet pressure.
8. Positive-pressure gas valves, for all gas types, shall be manufacturer cleaned, degreased, purged, sealed, and bagged for oxygen service, in accordance with CGA G-4.1.

    a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

2.6 GAS-SERVICE CONNECTION OUTLETS

A. Gas service connection types and configurations are subject to review and approval of the facility management group. The following outlets are a basis of design selection. Final connection outlets are to be selected by the facility management group.

B. Approved manufacturers:

1. Amico
2. Beacon Medaes
3. Pattons Medical
4. Ohio Medical

C. General Requirements for Medical and Laboratory Gas-Service Connections:

1. All positive-pressure gas-service connections, for all gas types, shall be manufacturer cleaned, purged, and sealed as for oxygen service in accordance with CGA G-4.1.
2. Suitable for specific gas pressure and suction service listed.
3. Include roughing-in assemblies, finishing assemblies, and cover plates.
4. Recessed-type units made for concealed piping unless otherwise indicated.

D. Roughing-in Assembly:

1. Steel outlet box for recessed mounting and concealed piping.
2. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
3. Double seals that will prevent gas leakage.
4. ASTM B819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.

E. Finishing Assembly:

1. Brass housing with primary check valve.
2. Double seals that will prevent gas leakage.
3. Cover plate with gas-service label.

NOT FOR BIDDING PURPOSES

F. Quick-Coupler Pressure Service Connections: Outlets for oxygen with noninterchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.

G. D.I.S.S. Pressure Service Connections: Outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.
   1. Medical Oxygen: D.I.S.S. No. 1240.

H. Cover Plates: One piece, aluminum and permanent, color-coded, identifying label matching corresponding service.

2.7 BULK MEDICAL GAS STORAGE TANKS

A. Bulk oxygen gas storage tanks, associated evaporating equipment and controls will be provided by turn-key medical gas supplier leasing agreements in coordination with the facility owners management group. These components are not included within this project scope.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:

   1. Clean medical gas tube and fittings, valves, gauges, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service in accordance with CGA G-4.1.
   2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb (0.453 kg) of chemical to 3 gal. (11.3 L) of water.

      a. Scrub to ensure complete cleaning.
      b. Rinse with clean, hot water to remove cleaning solution.

3.2 INSTALLATION OF PIPING

A. General Location and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of gas piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Comply with NFPA 99 for installation of medical gas piping.

NOT FOR BIDDING PURPOSES

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

F. Install piping adjacent to equipment and specialties to allow service and maintenance.

G. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.

H. Install piping to permit valve servicing.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and for branch connections.

K. Install medical gas piping to medical gas-service connections specified in this Section, to medical gas-service connections in equipment specified in this Section, and to equipment specified in other Sections requiring medical gas service.

L. Piping Restraint Installation: Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration Controls for Plumbing Piping and Equipment."

M. Install medical gas-service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

N. Connect gas piping to gas sources and to gas outlets and equipment requiring gas service.

O. Install unions in copper tubing adjacent to each valve and at final connection to each specialty and piece of equipment.

P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220500 "Common Work Results for Plumbing."

Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220500 "Common Work Results for Plumbing."

R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220500 "Common Work Results for Plumbing."

NOT FOR BIDDING PURPOSES

3.3 INSTALLATION OF VALVES

A. Install shutoff valve at each connection to gas laboratory and healthcare equipment and specialties.

B. Install check valves to maintain correct direction of gas flow from laboratory and healthcare gas supplies.

C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Arrange valves so largest valve is lowest. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install pressure regulators on gas piping where reduced pressure is required.

F. Install emergency oxygen connection with pressure-relief valve and full-size discharge piping to outside, with check valve downstream from pressure-relief valve, and with ball valve and check valve in supply main from bulk oxygen storage tank.

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

C. Threaded Joints: Apply appropriate tape to external pipe threads.

D. Brazed Joints: Join copper tube and fittings in accordance with CDA's "Copper Tube Handbook," Ch. "Brazed Joints." Do not use flux. Continuously purge joint with oil-free, dry nitrogen during brazing per NFPA 99 regulations.

E. Soldered Joints: Apply ASTM B813, water-flushable flux to tube end. Join copper tube and fittings in accordance with ASTM B828.

F. Extruded-Tee Outlets: Form branches in copper tube in accordance with ASTM F2014, with tools recommended by tube manufacturer.

G. Flanged Joints:

1. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts in accordance with ASME B31.9 for bolting procedure.
2. PVC Piping: Install PVC flange on PVC pipes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts in accordance with ASME B31.9 for bolting procedure.

H. Install bulk gas storage tanks and reserve supply tanks with seismic restraints.

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3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration Controls for Plumbing Piping and Equipment."

B. Comply with requirements for hangers, supports, and anchor devices specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

C. Vertical Piping: MSS Type 8 or Type 42, clamps.

D. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44 pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

F. Base of Vertical Piping: MSS Type 52 spring hangers.

G. Install hangers for copper tubing with maximum horizontal spacing and minimum rod diameters to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

H. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

I. Support vertical runs of copper tubing to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 IDENTIFICATION

A. Install identifying labels and devices for specialty gas piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Install identifying labels and devices for healthcare medical gas piping systems in accordance with NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:

1. Oxygen: White letters on green background or green letters on white background.

3.7 FIELD QUALITY CONTROL FOR HEALTHCARE FACILITY MEDICAL GAS

A. Testing Agency:

1. Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

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C. Tests and Inspections:

1. Gas Piping Testing Coordination: Perform tests, inspections, verifications, and certification of medical gas piping systems concurrently with tests, inspections, and certification of [**medical compressed-air piping**] [**and**] [**medical vacuum piping**] systems.
2. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:

    a. Initial blowdown.
    b. Initial pressure test.
    c. Cross-connection test.
    d. Piping purge test.
    e. Standing pressure test for positive-pressure medical gas piping.
    f. Standing pressure test for vacuum systems.
    g. Repair leaks and retest until no leaks exist.

3. System Verification: Perform the following tests and inspections in accordance with NFPA 99, ASSE Standard #6020, and ASSE Standard #6030:

    a. Standing pressure test.
    b. Individual-pressurization cross-connection test.
    c. Valve test.
    d. Master and area alarm tests.
    e. Piping purge test.
    f. Piping particulate test.
    g. Piping purity test.
    h. Final tie-in test.
    i. Operational pressure test.
    j. Gas concentration test.
    k. Air-purity test.
    l. Verify correct labeling of equipment and components.
    m. Verify medical gas supply sources.

4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed, and certify report results. Include the following:

    a. Inspections performed.
    b. Procedures, materials, and gases used.
    c. Test methods used.
    d. Results of tests.

D. Piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 PROTECTION

A. Protect tubing from damage.

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B. Retain sealing plugs in tubing, fittings, and specialties until installation.

C. Clean tubing not properly sealed, and where sealing is damaged, in accordance with "Preparation" Article.

3.9 PIPING SCHEDULE

A. Medical Oxygen Gas Piping NPS 3/4 (DN 20) and Smaller Operating at More Than 185 psig (1275 kPa): Type L, copper tube; wrought-copper fittings; and brazed joints.

3.10 VALVE SCHEDULE

A. Shutoff Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions.

B. Zone Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions with pressure gauge on one copper-tube extension.

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SECTION 23 00 00

GENEREAL REQUIREMENTS FOR HVAC

PART 1 – GENERAL STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.1 RELATED DOCUMENTS:

A. Division 01 Specifications, General and Supplemental Requirements apply to this section with additions and modifications specified herein.

B. Instructions to Bidders, Bidding Forms, Forms of Agreement between Owner and Contractor, Contract Award Date, Starting and Completion Dates, Conditions of the Contract, Insurance Requirements, and other Owner Requirements will be furnished separately by the Owner. These documents, as well as any addenda issued, shall form a part of these Specifications, and this Contractor shall consult them in detail for instructions pertaining to their work.

C. Each trade contractor shall receive all drawings and specification sections issued as part of the overall bid package. All contractors are to receive, review, and coordinate all of their work as shown or referenced on the other trade documents. All work shown or referenced on the other trade documents shall be included as part of the overall project scope for that particular discipline and trade.

1.2 SCOPE OF WORK:

A. These specifications and accompanying drawings are intended to cover the furnishing of all labor, material, and equipment and superintendence of the HVAC System for this project. They are also intended to cover performing all miscellaneous operations including excavations and backfilling, cutting, channeling, chasing, and patching necessary for the installation of the HVAC systems, as shown on the drawings, as hereinafter specified, as directed by the Engineer, or as may be required for a complete and fully functional HVAC installation.

B. It is the intent and purpose of these specifications and accompanying drawings to cover and include each item, all materials, machinery, apparatus, and labor necessary to properly install, equip, adjust, and put into perfect operation the respective portions of the installations specified and to so interconnect the various items or sections of the work as to form a complete and properly operating whole.

C. Drawings and specifications have been prepared with best knowledge of conditions available at the time of design and are intended to be complementary. What is called for by one shall be as binding as if called for by both. Where conflicts occur between drawings and specifications, or between the HVAC documents and the documents of other disciplines, the situation shall be

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brought to the attention of the Design Professional before the work in question is installed. In case of conflict between provisions of the Specifications or between the drawings and the specifications, the more stringent requirement shall govern. Where a requirement is applied to a specific product, condition, system, or Specification Section which conflicts with a more general requirement elsewhere, the specific shall supersede the general. If any obscurities or discrepancies exist, they shall be brought to the attention of the Design Professional before bids are submitted. If they are not discovered before bids are submitted, the Design Professional shall be notified and shall render a decision. This decision shall be final.

D. Any equipment, apparatus, machinery, material, and small items not mentioned in detail, and labor not hereinafter specifically mentioned, which may be found necessary to complete or perfect any portion of installation in a substantial manner, and in compliance with the requirements stated, implied or intended in these specifications shall be furnished without extra cost. This shall include all materials, devices, or methods peculiar to the machinery, equipment, apparatus, or systems furnished and installed as part of the HVAC work and shall include major components if so required.

E. The general arrangement of piping, ductwork and equipment shall be as identified on the contract drawings. Carefully examine all contract drawings and be responsible for the proper fitting of materials and equipment in each location as indicated. Inasmuch as the drawings are generally diagrammatic, due to their small scale, it is not possible to indicate all offsets, fittings, and accessories, as may be required in the final installation. Carefully investigate the site, structural, and finish conditions affecting their work and arrange such work, accordingly, providing such fittings and accessories as may be required to meet such conditions, at no additional cost to the Owner. The right to make any reasonable change in location of apparatus, equipment, outlets or routing of conduit and wiring, up to the time of roughing-in, is reserved by the Design Professional without involving any additional expense to the Owner.

F. Should a bidder find discrepancies in or omissions from the drawings or specifications they shall notify the Design Professional before submitting their bid proposal. The Design Professional shall then send written instructions, via Addendum, to all known bidders. Oral instructions shall not be binding to either the Design Professional or the Owner.

G. In the case of discrepancies or conflicts between the Drawings and Specifications, typically the Drawings will take precedence in the case of quantitative issues, while the Specifications will take precedence for qualitative issues; or as specified in other Divisions; however, when the scale and date of the Drawings are the same, or when a discrepancy exists within the Documents and specific written direction cannot be obtained from the Design Professional, Bidders shall include the most stringent requirements. Obtain written clarification from the Engineer prior to installation.

H. Any such items not brought to the attention of the Design Professional prior to submission of the bids shall be subject to the interpretation of the Design Professional. All such interpretations shall be accepted by the Contractor and shall be incorporated into the construction in a timely manner, at no additional cost to the contract.

I. These Specifications are arranged in accordance with the Master Format 2016, 35 Division format. The Specification is to be read as a whole. Items or work called for on one paragraph or Section, shall be applicable to the entire work, unless specifically indicated otherwise. Specific contract scopes shall be as determined by the Prime Contractor or Construction Manager.

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1.3 DEFINITIONS:

A. The following are definitions of words found in the various Sections of Divisions 23 and on the associated Mechanical drawings:

1. "Concealed" shall indicate hidden from normal sight in furred spaces, shafts, ceiling spaces, walls, and partitions.
2. "Exposed" shall indicate work normally visible, including work in Mechanical or Electrical equipment rooms, tunnels, and similar spaces.
3. "Provide" (and tenses of "provide") – shall indicate "supply and install, complete in all respects, for a complete and fully functional installation."
4. "Install" (and tenses of "install") – shall indicate "secure in position, make all final connections complete, test, verify and certify for a complete and fully functional installation."
5. "Furnish" (and tenses of "furnish") – shall indicate "supply only, complete with all required accessories, mounting hardware, etc., for installation by others, or as spare "attic" stock for the Owner's future use."
6. "Engineer" shall indicate person, firm or Corporation representing the Owner, and identified as such in the Contract Documents. The terms "Engineer" and "Architect" may be used interchangeably throughout the documents.
7. "Authority Having Jurisdiction (AHJ)" shall indicate the organization, office, or individual responsible for enforcing the requirements of the applicable codes or standards in the location where the project is to be constructed.
8. "BAS" shall indicate Building Automation System, and which shall also refer to by equivalent to references to "ATC" – Automatic Temperature Controls, "BMS" – Building Management System or "FMS" – Facility Management System. Any and all of these terms and acronyms may be used interchangeably to refer to the same functional system, specified under Divisions 21 - 25.

1.4 LAWS, REGULATIONS AND CODES:

A. Perform all work in strict compliance with all laws, regulations, and/or codes applying, including all Federal, State, and local codes and any other authority having jurisdiction. Wherever drawings or specifications conflict with such regulations they shall be made to conform, and approval of the Design Professional obtained on such changes as may be involved.

1.5 QUALITY ASSURANCE:

A. Comply with the requirements of the following codes and/or standards:

1. 2012 International Building Code (IBC) with applicable Delaware amendments
2. 2018 International Mechanical Code (IMC) with applicable Delaware amendments
3. 2018 International Energy Conservation Code (IECC) with applicable Delaware amendments
4. 2021 NFPA 101– Life Safety Code of Delaware
5. 2018 NFPA 90A – Standard for Installation of Air-Conditioning and Ventilating Systems
6. 2021 ASHRAE Handbook – Fundamentals
7. 2016 ASHRAE Handbook – HVAC Systems and Equipment

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8. 2020 ASHRAE Standard 55 – Thermal Environmental Conditions for Human Occupancy
9. 2019 ASHRAE Standard 62.1- Ventilation for Acceptable Indoor Air Quality
10. 2019 ASHRAE Standard 90.1- Energy Standard for Buildings
11. 2022 ASHRAE Standard 15 - Safety Standard for Refrigeration Systems
12. 2017 ASHRAE Standard 170 with 2020 addendums
13. FGI Guidelines for Design and Construction of Residential Health, Care, and Support Facilities 2022
14. 2021 Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)
15. Delaware Health and Social Services (DHSS)
16. SMACNA HVAC Duct Construction Standards – Metal and Flexible

B. All packaged equipment shall be independently Third Party labeled as a system for its intended use by a Nationally Recognized Testing Laboratory (NRTL) in accordance with the OSHA Federal Regulations 29CFR1910.303 and .399, as well as NFPA Pamphlet #70 and National Electric Code (NEC), Article 90-7

1.6 PERMITS, FEES, AND CERTIFICATES OF APPROVAL:

A. Unless stated otherwise in General Conditions or Division 01, obtain and pay for all permits, fees, and licenses required, including those of utilities and Agencies. Provide copies to Design Professional in the quantity requested.

B. "Fees" shall include connection charges construction costs, and other such charges by utility companies or service providers. Ascertain such charges during bidding period and include bid price.

1.7 REQUEST FOR INFORMATION (RFI):

A. Contractor is responsible for submitting Requests for Information (RFI)s when discrepancies arise, logical discrepancies are found on the contract documents, or clarification is necessary. All RFIs must be clearly written and submitted with a suggested solution. All RFIs regarding changes to the intent indicated on plans must be accompanied by sketches, explanation, site pictures, and all other instruments necessary, to clearly convey the issue at hand and the suggested solution. The RFI process may only be utilized for legitimate purposes. RFIs may not be utilized to submit deviation or substitution requests, nor requesting confirmation of scope for items clearly defined on the contract documents, nor related to clarifications that should be resolved through the Contractor's coordination efforts. RFIs that do not comply will be summarily rejected and any delays caused as a result are the responsibility of the Contractor. In cases where the Contractor does not submit an RFI to clarify an issue and incorrectly proceeds, all work required to resolve such issues to be in compliance with the intent of the contract documents, as determined by the Engineer, shall be the Contractor's responsibility and at no additional cost to the project.

B. The contractors are required to carefully examine all architectural and structural drawings for the building as well as all of the drawings for electrical trades, IT/AV/Security Trades, mechanical trades, plumbing trades and fire protection trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit or equipment. Refer to the coordination drawing requirements. Proper

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judgment shall be exercised to secure best possible headroom, ceiling heights, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment, and conduit, and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.

1.8 RECORD DRAWINGS:

A. Throughout the construction keep an accurate, up-to-date record of all deviations of the work between that as shown on the drawings and that which is actually installed.

B. Obtain a complete set of prints of the Mechanical drawings and note changes thereon. The design professional will provide the CAD files or Revit model for the contractor's use. Make a complete record in a neat and accurate manner, of all changes and revisions to original design which exist in completed work. As-Built markups shall be updated on a daily basis.

C. Submit As-Built documents in electronic BIM file format. The project design files will be provided to the Contractor by the Design Professional following proper execution of the Document Release and Indemnity Form as provided by the Design Professional. The electronic files returned by the Contractor shall be fully compatible with the native Revit *.rvt file format software used by the Design Professional to create the original documents. In addition, submit a complete set of drawings in PDF format.

D. Room names and numbers shall be brought up to date to reflect actual project room signage and designations, which may be different from room indications shown on the contract drawings.

E. The cost of preparing these record drawings shall be borne by the Contractor. When all revisions showing the work as finally installed are made, the prints and BIM files shall be submitted for review and approval by the Design Professional.

F. Record drawings shall be delivered to Owner within 30 days of project Substantial Completion.

1.9 OPERATION AND MAINTENANCE MANUALS:

A. Provide for the Owner's Use one (1) hard copy printed version and three (3) electronic copies in PDF format of a facility Operation and Maintenance Manual.

1. Each hard copy Manual shall be bound in an extra heavy duty three-ring loose-leaf binder with the following title lettered on the front "Record and Information Manual Homestead Wakefield Elementary School". No sheets larger than 8-1/2" x 11" shall be used, except sheets that may be neatly folded to 8-1/2" x 11" and used as a pullout.
2. Each electronic format Manual shall be provided as a single .PDF file, fully bookmarked and indexed, containing all Owner's Manual data and project drawings.

B. Provide the following information in each Manual:

1. Cuts of all equipment with manufacturer's technical specifications. Material shall be manufacturer's brochures, catalog cuts, parts lists, wiring diagrams, etc. Also include approved shop drawings.

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2. Operation, Maintenance and Servicing Procedures. Include frequency of inspection, cleaning and adjusting and other attention as may be required in accordance with manufacturer's instructions.
3. Copy of project Warranty.
4. Contact name, telephone number and email address for obtaining replacement parts and service for all equipment.
5. Copy of all individual equipment warranties.
6. Copies of all required Test Reports.
7. USB drive with all Special Systems drawings in both PDF and editable format.
8. Electronic copy of all Owners Instruction and Training Sessions.

C. Furnish qualified personnel to instruct the Owner's personnel in the maintenance and operation of all equipment and systems. Instructing personnel shall remain on the job continuously during working hours until such instruction is complete, but not less than 16 hours.

D. A video recording in digital format of the operator training session shall be made during this training period and the digital video submitted to the Owner with the Operation and Maintenance Manuals.

1.10 WARRANTY:

A. The material and workmanship of all parts of the mechanical installations specified herein and shown on the drawings shall be warranted unconditionally for a period of two (2) years from date of Project Substantial Completion against mechanical and electrical defects arising from faulty materials or workmanship. Either replacement or repairs shall be made promptly on any defective materials or workmanship without charge for materials, equipment, or labor during that period.

B. Manufacturer’s warranties on equipment provided under this contract shall be included in the operating and maintenance manuals.

C. See specification section regarding restrictions on Early Use of HVAC Equipment.

1.11 CORRECTION OF WORK AFTER FINAL PAYMENT AND WARRANTY:

A. This article is supplementary to Warranty Provisions of Division 01 and General Conditions.

B. Final payment shall not relieve the Contractor of responsibility for correction of faulty equipment, materials, and workmanship and, unless otherwise specified, they shall remedy any defects due thereto and pay for damage to other work resulting therefrom, which shall appear within the warranty period specified above.

C. Include warranties by the respective equipment manufacturers which shall be subject to the terms and time limits defined under these Divisions of Specifications.

D. Warranties furnished by Sub-Contractor and/or equipment manufacturers shall be counter-signed by the related Prime Contractor for joint and/or individual responsibility for subject item.

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E. Manufacturers' equipment guarantees or warranties extending beyond the warranty period described herein shall be transferred to the Owner along with the Contractor's warranties.

1.12 COMMISSIONING:

A. Commissioning: Division 23 Contractors and vendors shall be part of a total building and system commissioning effort as conducted by the Commissioning Agent. Each contractor shall provide a technician and tools required to assist and facilitate the commissioning agent, as outlined by the commissioning plan. Where applicable and required, the contractor shall secure and pay for a factory technician to be part of the startup, testing and commissioning team and efforts. Full scope of work and all related responsibilities will be defined in Commissioning documentation.

B. All equipment shall be commissioned, and the operation of that equipment shall be checked by the installing contractor. Specific systems shall be commissioned when more than one contractor is involved in the installation or there is multiple system interface and control involved with that piece of equipment.

C. The contractors shall check and verify all equipment nameplate data against the design parameters, prior to installation.

D. The contractors shall submit a Spare Parts List for all equipment in the Maintenance and Operations Manuals to include, but not limited to the following:

1. Part Numbers.
2. Part and Equipment Description.
3. Quantity of Parts Required.
4. Lubrication Requirements.
5. Full Warranty Information.
6. Complete Operation and Maintenance Manuals.

E. Provide factory trained technician after successful startup, for on-site support. Allow for five (5) days on-site for this. These days may not be consecutive.

F. Provide six (6) additional site visits, after hours, after successful commissioning in the first year. For additional training and troubleshooting.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT:

A. All installed materials and equipment shall be new and the best of their kind and shall conform to the grade, quality and standards specified herein.

B. Unless otherwise specifically stated, all materials and equipment offered under these specifications shall be limited to products regularly produced and recommended by the manufacturer for the service intended. This material and equipment shall have capacities and ratings sufficient to amply meet the requirements of the project. The capacities and ratings

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shall be in accord with engineering data or other comprehensive literature made available to the public by the manufacturer and in effect at the time of opening of bids.

C. Equipment shall be installed in accordance with manufacturer's instructions for type and quality of each piece of equipment used. These instructions shall be obtained from the manufacturer and shall be considered part of these specifications. Type, capacity and application of equipment shall be guaranteed suitable to operate satisfactorily. No experimental material or equipment shall be permitted.

2.2 WORK INCLUDED:

A. In addition to work described above under WORK DESCRIPTION, the work shall include but not necessarily be limited to the following:

1. Furnish and install all new scope as noted herein and shown on drawings.
2. Rigging of equipment and materials related to the HVAC Work.
3. Concrete work as specified hereinafter.
4. Excavation and backfill.
5. Mounting of duct smoke detectors furnished under Division 28.
6. Ductwork and piping leak testing.
7. Pipe, valve, and equipment marking and tags. Painting as noted herein.
8. Test, adjust and balancing of all ductwork, piping and equipment.
9. Any and all shutdowns shall be scheduled with the Owner and performed at such times as the Owner may direct. Required premium time shall be included in the Contractors bid.
10. Where the specification requires testing, factory and/or field start-up, commissioning, adjustments, warranty or other activity, such requirements shall apply to each individual phase of the work.
11. Support of independent commissioning agent retained by Owner.
12. Where work of one phase extends from or interfaces with previous work, services for the latter phase shall include previously installed components. At the end of all work all such systems or equipment shall be tested or adjusted in their entirety in completed form, even if tests are redundant with previous phases.
13. Instruction and equipment manuals. Instruction of Owners representatives.

2.3 EXCAVATION AND BACKFILL:

A. Perform all excavating and backfill necessary for work under this Contract. It is assumed that all excavation under this Contract will be soil excavation. In event that rock is encountered, the Contractor shall be compensated for rock excavation in accordance with the unit prices or soil and rock excavation. Bidder shall state in their proposal, the unit prices for soil and rock excavation and the unit prices for soil excavation to be omitted. Rock excavation shall consist of solid rock or boulders over two cubic yards in volume or other material which can only be removed by line drilling or chipping by power equipment; blasting will not be permitted. In event rock is encountered notify the Design Professional of its existence in the areas not to be excavated and accurate measurements of the extent of the rock actually removed shall be made and submitted to the Design Professional.

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B. Perform all excavating and backfill necessary under this contract. All excavation shall be unclassified, and includes the excavation and removal of all soil, shale, rock boulders, existing foundations, fill and every kind of sub-surface condition encountered in the contract area. No extra or additional compensation for excavation will be paid under this Contract.

C. To protect persons from injury, and to avoid property damage, adequate barricade, construction signs, torches, lanterns, and guards shall be placed and maintained during the progress of the construction work and unit it is safe for traffic use. Rules and regulations of local authorities respecting safety provisions shall be observed.

D. The excavation may be accomplished by machine to within 2 inches of the sub-grade elevation. The excavation shall be completed by hand to neat lines.

E. Trenches shall be instrument graded using batter board and flow line and of sufficient width to provide a free working space of not less than 24 in. width and not greater than 12 in. on each side of the pipe barrel, whichever is greater. Trenches shall also be wide enough to thoroughly ram the backfilling around the pipe and to secure a firm bed.

F. In earth excavation, the trench shall be carried to the invert of the pipe. Where rock excavation is encountered, the trench shall be carried to a point 6 in. below the construction. No construction shall be bedded directly upon rock but shall be cushioned by a 6 in. layer of selected crushed stone or gravel.

G. Where material is removed below the grade of the bottom of a structure it shall be replaced with concrete of the same quality as the concrete in the structure. Where material is removed below the grade of a pipe trench it shall be replaced with a lean concrete mix. Make no excavation to depth below a line of slope one ft. rise on 2 ft. length from such excavation to bottom of footing on other construction.

H. Any piping that is run in unstable ground shall be supported on 5'-0" centers with concrete or brick piers. These piers shall be not less than 12 inches square and must reset on solid ground. Brick piers shall be laid in cement mortar.

I. Maintain banks at all times by means of shoring and bracing to avoid cave-in and make good any damage done to property or work of others due to failure to properly shore any excavation. Shoring done shall be removed after installation and test of lines have been approved. Material for shoring shall be placed in accordance with the regulations of the Department of Labor and Industry.

J. All excavations shall be left open until inspected and approved by the Design Professional. After the work has been installed, tested inspected, the excavation shall be backfilled with the best carefully selected materials free from stones, large pebbles, hard lumps on frozen earth. Trenches shall not be backfilled until the work has been inspected and approved by the Design Professional. All backfill shall be made in 8 in. layers. The first 2 layers shall be fine earth, hand tamped. The remainder of the fill over new construction to the surface shall be ordinary approved excavated material placed in 8 in. layers and thoroughly compacted to not less than 90% of maximum Modified Density as determined by ASTM D 1557-70. No water soaking will be permitted. All excess materials shall be disposed of as directed. Seeding shall be by the Prime Contractor.

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K. Where excavation is required under existing walkways and roadways, surface shall be restored with new materials equivalent to the material originally used. Whole cement pavement blocks shall be removed and replaced; removal and repair of partial blocks is not permitted. Edit the above section as required.

2.4 PUMPING:

A. Provide pumping equipment to pump all water to prevent it from collecting in trenches, basement areas, and any other excavations necessary to carry out contract requirements. Prepare run-off trenches as required to pump water into and use surplus earth to form dam at top of excavation to run back surface water.

2.5 CHASES AND OPENINGS:

A. Provide information to the appropriate trades regarding size and location of all openings and chases as required for the installation of this HVAC Work.

B. Patching and repair of finishes will be by the Prime Contractor.

C. Provide sleeves for pipes passing through poured concrete decks, footings, walls, etc. Cut all openings for piping passing through precast concrete or existing concrete or masonry. Such holes shall be cut with core drill or similar equipment. They shall not be cut with hammer and chisel, or with any power tool depending on impact for its cutting power.

2.6 CONCRETE:

A. Provide concrete work required for work performed under this Contract. Coordinate with work shown on Structural Drawings.

B. Concrete shall have a compressive strength of 3,000 psi minimum at twenty-eight days. Placing of reinforcing steel and concrete shall be done according to the recommendations of the American Concrete Institute and Concrete Reinforcing Steel Institute, and all materials shall conform to American Society for Testing Materials Specifications, applicable to this work. Equipment pads shall be properly dowelled in with floor construction and shall have sloped bevels on all horizontal and vertical edges.

C. Form work shall be of sufficient strength to maintain desired shape during pouring of concrete and tight enough to prevent leakage of the grout through joints.

D. Submit shop drawings for approval showing dimensions, reinforcing, and dowelling.

E. Provide at the time of pouring concrete, all necessary anchor bolts. Anchor bolts shall be the hook type, of proper size and length to suit the equipment. Anchor bolts shall be set in pipe sleeves of approximately twice the bolt diameter and one half the embedded length of the bolt. Assume full responsibility for proper emplacement of the bolts.

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F. Drop-in wedge anchor bolts or self-drilling anchors may be used in place of hook bolts. Minimum embedment in concrete of wedge anchor bolts shall be in accordance with manufacturer's instructions. Wedge anchor bolts shall be manufacturer by Phillips Drill Co. or USM Corp. Self-drilling anchors shall be manufactured by Phillips Drill Co.

G. After equipment is set in place and bolted down, any space between equipment base and floor slab or foundation shall be completely filled with non-shrink grout equal to Master Builders Co., Ltd. Embeco 153 grout.

2.7 STARTERS AND PILOT DEVICES OR MOTOR CONTROLS:

A. Combination magnetic motor starters shall be full voltage non-reversing with an adjustable instantaneous-trip circuit breaker or fused or unfused safety switch. Motor starters shall have UL508 symmetrical RMS ampere interrupting rating in accordance with equipment specifications or as required by Electrical Coordination Study specified in Electrical General Requirements: Division 26. Starters and protective devices shall be of sizes recommended by manufacturer for the motor to be controlled, but minimum size shall be NEMA size 1. Overloads shall be solid state type which provide both overcurrent as well as phase loss protection at motor.

B. Combination magnetic motor starters shall be full voltage non-reversing with a fused safety switch. Starters and protective devices shall be of sizes recommended by manufacturer for the motor to be controlled, but minimum size shall be NEMA size 1.

C. Starters, which are not combination shall be similar, but without circuit breaker or switch.

D. For description of starters, refer to Division 23 and 26 Specifications. This Schedule describes which starters are combination, and if so, what type of device they require. This Schedule also indicates the type of pilot device(s), indicators, auxiliary relays, etc. to be supplied. In the absence of any such instruction, furnish non-combination starter with "hand-off-auto" selector switch, green "run" pilot light, and two (2) auxiliary contacts.

E. Where starters or other devices are to be mounted outdoors, such as on a cooling tower, enclosures shall be NEMA Type 4. All other enclosures, unless otherwise noted, shall be NEMA Type 1.

F. All starter control circuits shall be 120V (or 24 VAC if required to interface with BMS/BAS equipment). Voltage shall be derived from starter line voltage via fused control transformer. Control transformers shall have sufficient capacity to properly operate any auxiliary equipment, such as dampers, electro-pneumatic switches, or other devices. Provide transformers larger than manufacturer's standard size, as required by these conditions. Provide sufficient auxiliary contacts to properly interface with ATC equipment, or other devices interlocked with the motor in question.

G. Manual starters shall be toggle type, in surface or flush enclosure as required, and with pilot light. Provide overload heaters unless the motor to be controlled is thermally protected.

H. Unless otherwise noted, overload heaters shall be melting-alloy non-automatic-reset type. Overload heaters shall not be selected based on average published motor currents but shall be selected based on the actual nameplate current of motors and service factor as installed.

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I. Push buttons, selector switches, pilot lights and similar pilot devices shall be NEMA 1 or NEMA 4, as noted in D, above. Pilot lights shall be neon or transformer type. Provide manufacturer's standard engraved nameplates which display the control function of the device (or for pilot lights, the action indicated).

J. Electrical Contractor shall install all individually mounted starters. Electrical Contractor shall provide line and load side power wiring. Coordinate with Mechanical Contractor for all BMS/BAS control interface/interlocks. Mechanical Contractor shall turn over all starters to the Electrical Contractor for installation. This Contractor shall furnish, install, and wire all other (pilot) devices, and provide cell control wiring for starters. See Division 23 “Sequence of Operations” Specification for additional details.

K. All starters and controls shall be Square D, General Electric, Allen Bradley, Cutler-Hammer or Siemens.

2.8 ELECTRICAL WORK AND MOTORS:

A. All electrical work shall be done in strict accordance with the requirements of the National Electrical Code and the Electrical Specifications. All electrically operated equipment shall bear an Underwriter's Laboratories label where labeling service is available for that type of equipment.

B. All motor frames shall be grounded. Electric power, control and grounding connections shall be factory wired to an outlet box or terminal strip enclosure on the apparatus for easy connection by the Electrical Contractor.

C. All motors shall be designed and constructed in accordance with the latest standards of the IEEE and NEMA and shall meet UL requirements. Motors shall run quietly under all operating conditions.

D. See Division 23 Specification for additional details.

2.9 WIRING FOR CONTROL SYSTEMS:

A. This Article applies to wiring used for Automatic Temperature Control (ATC), Building Automation Systems (BAS), Building Management System (BMS), and similar types of control systems associated with work of Division 23.

B. All wiring for control systems shall comply with Article 725 of the National Electrical Code, (NEC) or with Articles 760, 800, or 820 for control systems integrated into systems covered by those Articles.

E. Particular attention shall be given to the requirements of the NEC for testing and labeling cables for use in plenums, risers, and other air-handling spaces.

C. All wiring for control systems shall be of a type recommended by the system manufacturer and be installed in accordance with systems manufacturer's instructions.

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D. Cables must be in raceways when run through inaccessible ceilings, walls or chases. Comply with Division 26 Specifications, for types of raceways required and their installation requirements. Cables run on surfaces within 8' of finished floor must be in raceways where exposed to physical damage. Cables in mechanical spaces must be in raceways.

1. Where cables enter or leave raceways, provide insulated bushing or protective grommet.

E. Cables may be run without raceways above accessible ceilings; in hollow stud partitions; and where properly supported in unfinished spaces without ceilings.

F. Cables run without raceways in concealed locations or unfinished spaces shall be supported by bridle rings or similar hangers attached to the building structure at maximum 5'-0" centers. Hangers and/or cables shall not be supported from pipes, ducts, or similar equipment. Cables shall not be supported by lying on or across framing members or structural elements.

G. Where cable is run exposed in finished areas, it shall be supported by bridle rings and beam clamps at maximum 4' intervals. All cables running along a given beam, joist, or truss shall be bundled together and run parallel to each other. Bundle shall be tied together at 2' intervals with T&B “Ty-raps” or equal nylon cable tie. Ty-raps shall be exposed one foot on either side of bridle ring supports. Cables shall be pulled as tight as possible and run as straight as possible.

1. Where cables bend, bends shall be 90 degrees; parallel cables shall have symmetrical turns. Bending radius shall be no smaller than manufacturer’s specification for level of cable involved. Individual cables shall be supported with metal straps listed for the purpose. All cables shall be run parallel with or perpendicular to building lines, plumb and true. Cable loops connecting to boxes or fittings shall be as short and neat as possible.

F. See details on Electrical Drawings for general information regarding cable support. All cables run on steel structure will be painted to match steel; cable supports, ties, etc., must be installed prior to painting.

G. Cables shall be maintained at a spacing of 6" from 120 V and higher voltage AC conductors, unless installed in a grounded metallic raceway.

H. Wiring with or without raceways shall be run continuously between terminal boxes and outlets. All splices shall be made in NEMA 1 boxes with terminal strips or other acceptable connectors and permanent labels to identify each wire and cable, both entering and leaving the box.

I. A separation of not less than 6" shall be maintained to heated pipelines.

J. Cable run above hung ceilings used for environmental air shall be specifically listed and labeled for the use or shall be installed in a raceway.

K. Wiring run without raceways through rated walls, floors and partitions shall be run in sleeves. All such sleeves shall be packed with fire-rated material.

L. Wiring for different systems shall be grouped and run separately from other systems and shall be identified as to the system it serves.

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M. Where equipment to be provided is controlled with line voltage devices (thermostats, speed controllers, timers, etc.), these devices shall be furnished to the electrical contractor for mounting and wiring of same.

N. All electrical wiring in connection with the BAS shown on the electrical drawings shall be installed by the Electrical Contractor. Any wiring not shown but required for proper operation of the automatic temperature control system, shall be performed by the Control Contractor and shall be in complete accordance with National Electrical Code, latest edition, and the Electrical Contract Specifications.

2.10 FLASHING AND ROOFING WORK:

A. The Contractor shall perform all cutting, patching, and sealing of existing roofs as required for the installation of all work under this Contract.

B. The contractor bears the complete responsibility for maintaining and obtaining the watertight integrity of the affected areas of the roofs both during and after the completion of construction.

C. The Contractor shall provide all base flashings, counter flashings, and hot applied roofing materials necessary to properly flash and seal the roofs as required and to prevent any water or moisture leakage whatsoever from occurring as a result of this work.

D. Unless noted otherwise, all flashings shall be minimum 24-gauge galvanized steel. Base flashings shall have minimum 4" roof flanges on all sides. Flanges of all base flashings shall be secured and stripped into existing roofing in accordance with the best practices and methods of the roofing trade for a watertight installation.

E. All joints and seams of all flashings shall be continuously soldered.

F. After installation, all exposed metal surfaces of base flashings shall be given two (2) applications of roofing coating.

G. All roofing work shall be performed by first class mechanics experienced in the roofing trade.

H. Contractor must exercise extreme care so as not to damage existing roofs while working thereon and they shall provide protection planking and plywood as required to achieve this result. Any damage to the existing roofs and their watertight integrity caused as a result of work being performed under this Contract shall be properly repaired by the Contractor to the satisfaction of and at no cost to the Owner.

I. Refer to drawings for additional flashing details and roofing work required.

2.11 SUBSTITUTIONS:

A. Equipment may be shown or specified in several ways:

B. Several manufacturers and model numbers listed; or one manufacturer and model number, followed by "equals by (mfr A), (mfr B), (mfr C)," or words of similar respect.

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D. If one of the manufacturers is listed on the drawings, that manufacturer shall be considered the basis of design. If none is so listed, the first manufacturer named in the Specification shall be considered the basis of design.

E. Where manufacturer's or supplier's name, style and catalog numbers are mentioned in the description of material and equipment in the specifications or on the drawings, it is to be understood that they are for the purpose of setting a standard.

F. If Contractor elects to furnish equipment other than the basis of design, they shall verify capacities, physical size, weight, electrical requirements, methods of connection to other parts of the system, and all other relevant data. Contractor shall be responsible for informing the Design Professional of all changes required to other equipment, spaces, structure, or systems in order to install the substituted equipment. They shall furnish all required shop drawings or sketches required for Design Professional to evaluate the required changes and shall be responsible for all costs associated with such changes, including costs of design or engineering, if such are necessary, and costs of other trades.

G. Accompany the request for substitution review with a table of comparisons listing pertinent features of both the specified and proposed materials including performance data, weight, material of construction, overall length, width, height dimensions, space required for replacement or maintenance access, motor type, horsepower, voltage, phase service factor, and noise levels. Review of proposed substitution will not be made until receipt of the complete comparison tabulation.

H. Where manufacturer's or supplier's names are listed in conjunction with the manufacturer or supplier that is basis of design, they are given to approve the firm name only. Equipment or material submitted by such firms must meet the detailed technical specifications written for the respective item. Contractor shall be responsible for verifying capacities, physical sizes, weights, electrical requirements, and methods of connection to other parts of the system, etc. Contractor shall furnish all required shop drawings for equipment, and for its connection and installation.

I. If any substituted items are submitted after contracts have been awarded, and there is any question of equality of such items, samples may be required to be submitted both for the item specified and that to be substituted, or further proof of equality may be required to the entire satisfaction of the Design Professional. In no case shall additional remuneration be allowed because of the rejection of a substitute.

J. When the equipment is relocated to a place other than that shown on the drawings, or when equipment other than that specified is used, the Contractor shall pay the extra cost of required revisions such as structural steel, concrete, electrical, piping, etc.

K. The Design Professional's costs to evaluate substitutions and to revise Drawings and Specifications because of substitutions will be paid by the Contractor.

2.12 SHOP DRAWINGS:

A. Refer also to Division 01.

B. Furnish shop drawings, catalog cuts, performance data and other required data to the Design Professional for approval for all material and equipment specified hereinafter. Sufficient data shall be submitted to show compliance with the requirements of the plans and specifications. All shop drawings submitted shall be first checked and corrected before submitting for

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approval. Approval for shop drawings by the Design Professional will not relieve the Contractor from responsibility for errors or omissions therein. All such errors or omissions must be made good by the Contractor irrespective of any approval by the Design Professional.

C. It is the responsibility of the manufacturer's representative and the installing contractor to thoroughly review all shop drawing equipment submittals and state in writing that the products meet or exceed the design specifications and design intent as indicated on the contract documents, prior to submitting them for review by the engineer.

D. The Prime Contractor or Construction Manager shall review and stamp all shop drawings noting their review process has taken place and that the shop drawings are in compliance with the design documents, prior to submitting the for review by the engineer. Any shop drawings found to not be in compliance shall be returned to the contractor stating such, with a copy of the statement (only) forwarded to the engineer.

E. On submissions beyond the initial one, clearly identify all of the changes made from the initial submittal those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.

F. The Engineer will review three submissions (one original submission and up to two revised submissions) on any single component requested for review. If the contractor and/or vendor fail to comply with the drawings, specifications, and/or review comments and additional submissions are required, the cost for review and processing of those submissions will be borne by the contractor.

G. The design documents are based and coordinated on the scheduled manufacturers. Any substitutions of products or materials (from those approved and listed in the specifications) must be thoroughly coordinated by the submitting contractor. This includes but is not limited to power, space, structural, control and performance requirements.

H. Shop drawings required shall include, but not necessarily be limited to, the following:

1. Shop drawings, cuts and catalogue information showing appearance, dimensions, performance, weight, etc., of all equipment, appurtenances, etc.

I. Schedules of all materials showing type and manufacturer.

J. Wiring diagrams and schematics for equipment.

K. All special equipment and systems.

L. Any special constructions.

M. Other shop drawings as may be requested.

N. Ductwork shop fabrication drawings. See also the requirements in Part Three of this Specification Section.

O. Digital files of mechanical work will not be provided for the purpose of shop drawing preparation. Digital file purposes: architectural plans, elevations, sections, etc. may be

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available for background purposes; it is the responsibility of the Contractor to confirm availability prior to bid.

P. Shop drawings shall be submitted in a timely manner, taking due account of time requirements for processing, correcting, and distributing the shop drawings to all persons or trades requiring the information, as well as time required for manufacture of the equipment. Design Professional will not be responsible for construction delays resulting from late submission of shop drawings, nor for delays caused by the need to correct and resubmit shop drawings which were not correct, which involved substituted equipment, or otherwise required review, correction and resubmission.

Q. If Contractor elects to proceed to install equipment for which approved Shop Drawings have not been received, they do so at their own risk; Design Professional is not obligated to accept such equipment or work, nor will Design Professional be liable for claimed costs or delays required by correction of such work.

R. Identify each submittal, including shop drawings, catalog data, test reports, operation and maintenance manuals, and record documents, with the following data:

1. Buyer's name.
1. Project name.
2. Project location.
3. Buyer's purchase order number.
4. Reference specification order number.
5. Name of contractor making the submittal.
6. Revision level of submittal and date of revision.
7. For equipment, provide the following information on each submittal:
8. Equipment tag number.
9. Equipment description.
10. Equipment manufacturer's contact information.
11. Local equipment representative's contact information.

S. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristic, finishes for materials, and installation and startup instructions for each type of product indicated.

1. Each control device labeled with setting or adjustable range of control.

T. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Schematic flow diagrams showing all controlled equipment and control devices.

O. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.

P. Details of control panel faces, including controls, instruments, and labeling.

Q. Written description of sequence of operation.

R. Trunk cable schematic showing programmable control unit locations and trunk data conductors.

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S. Listing of connected data points, including connected control unit and input device.

T. System graphics indicating monitored systems, data point addresses, and operator notations.

U. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.

U. Shop Drawings shall be submitted and shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Shop drawings shall also contain complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, calculations, and any other details required to demonstrate that the system will function properly. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work.

V. Shop Drawings shall be approved before any equipment is installed. Therefore, shop drawings must be submitted in time for review so that all installations can be completed per the project completion schedule. Ten (10) working days shall be allowed for submittals to be reviewed by the Engineer.

W. All drawings shall be reviewed after the final system checkout and updated or corrected to provide "as-built" drawings to show exact installation. All shop drawings will be acknowledged in writing before installation is started and again after the final checkout of the system. The system will not be considered complete until the "as-built" drawings have received their final approval. The Contractor shall deliver a complete set of "as-built" drawings.

X. On submissions beyond the initial one, clearly identify changes made from the initial submittal other than those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.

V. Shop Drawing Review Comment Definitions

A> No Exception Taken:

The shop drawing or equipment submittal as submitted is approved without exception. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

B> Make Corrections Noted:

The shop drawing or equipment submittal as submitted is not completely correct but is approved as noted. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted can be released for fabrication and construction once the corrections have been made. The submittal must be corrected and resubmitted for record unless noted by "E: Resubmit". See "E: Resubmit definition below.

C> Submit Specified Item:

The shop drawing or equipment submittal as submitted is missing a component of the system that it represents or is not of the approved and specified manufacturers. Submit the missing or incorrect item. The materials, equipment or system submitted cannot be released for fabrication and construction.

D> No Further Submission Required:

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The shop drawing or equipment submittal as submitted is approved as noted. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

E> Resubmit:

The shop drawing or equipment submittal as submitted is not approved. The shop drawing or equipment submittal needs significant corrections and does require another submission to verify that the comments and changes have been incorporated. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted cannot be released for fabrication and construction.

F> Rejected:

The shop drawing or equipment submitted is not as specified or a non-approved manufacturer or product and rejected.

G> Resubmit for Record Only:

Make the corrections noted on the shop drawing or submittal. The shop drawing or equipment submittal as submitted is approved with minor exception. Changes or corrections are required. The materials, equipment or system submitted can be released for fabrication and construction.

PART 3 - EXECUTION

3.1 WORKMANSHIP:

A. All work shall be installed in a first class, neat and workmanlike manner by mechanics skilled in the trade involved. All details of the installation shall be mechanically correct. Should the Design Professional direct removal, change, or installation of any equipments or systems not installed in a neat and workmanlike manner, such changes shall be made by the HVAC Contractor at no expense to the Owner.

B. Equipment shall be installed in strict accordance with manufacturer's instructions for type and capacity of each piece of equipment used. The Contractor shall obtain these instructions from the manufacturer and these instructions shall be considered part of these Specifications.

C. Drawings are generally indicative of the work to be installed, but do not indicate all bends, fittings, and specialties which may be required, or the exact locations of all piping and ductwork. Contractor shall investigate structure and finish conditions affecting their work and arrange their work; accordingly, furnishing such fittings as may be required to meet such conditions. Contractor is responsible for exercising proper judgment to arrange their work and materials so as to avoid interference with other trades.

1. Riser diagrams and schematics generally indicate equipment to be used in various systems involved. This information may or may not be duplicated on the plans, but equipment shown on either plans or riser diagrams and schematics shall be provided as if shown on both.

D. All grades, elevations, dimensions and clearances of equipment shown on drawings are approximate and shall be verified at site.

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E. Where work or equipment is referred to in singular terms, such reference shall be deemed to apply to as many items of work or equipment as required to complete entire installation.

3.2 LINES AND GRADES:

A. Lay out work and establish heights and grades for work in strict accordance with the intent expressed by the drawings and all the physical conditions at the building and be responsible for the accuracy of same.

3.3 FIELD MEASUREMENTS:

A. Before ordering any material or doing any work, verify all measurements at the building and site and be responsible for the correctness of same. No extra compensation will be allowed on account of differences between actual dimensions and measurements and those indicated on the drawings. Any difference which may be found shall be submitted to the Design Professional for consideration before proceeding any further with the work.

3.4 DELIVERY OF EQUIPMENT:

A. Be responsible for delivery of equipment, unload and store in a manner not to interfere with the operation of other trades. Additional expense incurred because of equipment or material delivery delays shall be assumed by the responsible Contractor.

3.5 RESTRICTIONS ON EARLY USE OF HVAC EQUIPMENT:

A. The HVAC equipment provided under this contract shall not be operated prior to the completion of construction of the building for reasons other than testing and balancing of the systems, unless specifically directed and/or approved by the Owner. This specifically prohibits the use of permanent equipment for the purposes of ventilating, heating and dehumidifying the building while under construction.

B. Should a contractor choose to use any component of the permanent HVAC system (i.e. rooftop units, terminal units, etc.) for purposes other than stated above, they shall assume full responsibility for replacing or repairing any equipment damaged as a result of the use and pay all costs associated with the action required to make the equipment in “like new” conditions at the end of the project. This includes cleaning of ducts and coils, replacement of motors, extension of warranties, payment of design professional fees required to investigate and enforce this requirement, and the correction of any other detrimental conditions which is determined by the design professionals to be related to the early use of the equipment.

C. Should the early use of equipment result in manufacturer’s warranty being void, the contractor shall assume the cost of furnishing an equivalent warranty to the owner.

D. Should fan motors be operated during construction, any motor determined by the owner or design professional to be exposed to airborne construction dust, such as generated by drywall sanding, shall be inspected by an independent 3rd party for damage. The costs of all required

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corrective actions shall be borne by the contractor responsible for the operation of the equipment.

3.6 PROTECTION OF WORK:

A. All work, equipment and materials shall be protected at all times.

B. All piping openings shall be closed with caps or plugs during installation. All equipment shall be tightly covered and protected against dirt, water, plaster, paint and other foreign material or mechanical injury during entire progress of installation. Make good all damage caused either directly or indirectly by workmen employed to fulfill requirements of the HVAC Work.

C. Acoustically lined ductwork shall at all times be protected from weather.

3.7 REMOVAL OF RUBBISH:

A. During the course of construction, periodically remove from the premises all rubbish resulting from work of this trade so as to prevent its accumulation. At the completion of the work contemplated under these Specifications remove from the building and site all rubbish and accumulated materials of whatever nature not caused by the other trades and leave work, and equipment free of all foreign matter including plaster, cement, and paint and leave in a clean, orderly, acceptable and usable condition.

3.8 COORDINATION WITH OTHER TRADES:

A. Work in conjunction with each of the other trades to facilitate proper and intelligent execution of work with minimum interference.

B. Carefully examine all architectural and structural drawings for the building and drawings for electrical trade and other mechanical trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit or equipment. Proper judgment shall be exercised to secure best possible headroom, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment and conduit: and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.

C. Contractor shall prepare preliminary sheet-metal shop drawings suitable for use in coordinating their work with the work of other trades. The Mechanical Contractor shall prepare and furnish CAD files of drawings at 1/4" = 1'-0" scale illustrating the coordination with all trades. Drawing shall indicate equipment access requirements, piping, ductwork and conduit in relation to all structural elements of the construction, including floor elevations; steel locations, size, and elevations; partitions locations; door locations and direction of swing; and all other information required to assure coordination of the electrical, sheet-metal and piping trades and fire protection in relation to the Architectural function of the project. Coordination meetings shall be held under the supervision of the Owner's Construction Manager and Prime Contractor. Each trade shall have proper representation at all coordination meetings for the purpose of detailing, on a print of the coordinated drawing mentioned above, the exact location and routing

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of their work. After the conclusion of the coordination at the working meetings, each trade shall sign the coordinated print, copies of which shall be distributed by the GC to all contractors and parties concerned including the Owner. A print of each final coordination CAD drawing with the participants contractor's "signoff" signatures appended shall be submitted to the design professional for record.

D. If contractor installs work so as to cause interference with work of other trades, they shall make necessary changes in work to correct the condition without extra charge.

E. Dimensional layout plans of equipment rooms shall be made showing all bases, pads and inertia blocks required for mechanical equipment. Include dimensions of bases, bolt layouts, details, etc.

F. Contractor shall furnish all necessary templates, patterns, etc. for installing work and for purpose of making adjoining work conform, furnish setting plans and shop details to other trades as required.

3.9 COORDINATION OF CONTROL EQUIPMENT:

A. The HVAC Contractor shall furnish all starters, push buttons for local or remote control, controllers, pressure switches, aquastats, thermostats, float switches or similar items together with all appurtenances and accessories required to operate the equipment furnished under these specifications and necessary to perform the operating functions as specified, shown on the drawings, or otherwise required.

B. Refer to Schedule of Control Equipment on Drawings for type of controls required. The Electrical Contractor will mount and provide power-wiring for all starters and will furnish and install all other safety switches or other line-disconnecting or protective devices. Where the starter and/or safety switch is an integral part of the equipment assembly, the assembly shall be furnished with the wiring complete between starter, controller and motor and the Electrical Contractor will make power connections only.

C. All control wiring to automatic-operated switches, pressure switches, aquastats or other devices which actuate the starter or other items associated with the systems shall be furnished, installed and wired by the HVAC Contractor. The Electrical Contractor will supply 120V electric power to the control panels for these special systems to the extent shown on Electrical Drawings. All other wiring (including additional power circuit if required) shall be the responsibility of the HVAC Contractor.

D. The HVAC Contractor shall carefully check the current characteristics available to each location before ordering motors.

E. If procurement requirements necessitate a change in voltage, phase, horsepower or other characteristics of any motor, the HVAC Contractor shall obtain approval of such change from the Design Professional and shall be responsible for necessary arrangements for notifying the Electrical Contractor, and shall pay the costs, if any, required by the change, including Engineering costs.

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F. All electrical equipment furnished and installed under this contract shall be furnished with full complement of control equipment, control wiring, conduit and all other items necessary for satisfactory operation.

G. The Electrical Contractor will complete all electrical power connections, through the disconnect and/or thermal cutouts, starter and motor terminals. They will be responsible for final power connections.

H. The Electrical Contractor will be responsible for proper rotation of three phase equipment.

I. All electrical work, equipment and material furnished under this Section shall be furnished and installed in accordance with Division 26 Electrical Specifications.

J. All panels, relays, terminal boxes, contactors, circuit breakers, safety switches, motor starters and similar items shall be identified by Name, Function and/or Control. Nameplates shall be at least 1" x 3" with characters not less than ¼". They shall be made of two laminated black plastic sheets bonded with a middle sheet of white plastic and characters engraved in one black sheet to the depth of the white plastic. A typewritten list of Nameplates shall be submitted to the Design Professional for approval before ordering same.

3.10 EXPANSION OF PIPING:

A. All piping connections shall be made so as to allow for perfect freedom of movement of piping during expansion and contraction, without springing or creating air pockets which will impair the flow of the water through the system. Install expansion loops as shown on the drawing or as required. Expansion loops shall be made with swing joints, bends or long offsets as necessary. Provide expansion guides.

3.11 ANCHORS AND GUIDES:

A. Anchors shall be provided where shown and/or required for the proper control of stress in piping due to expansion.

3.12 ACCESS:

A. All equipment requiring maintenance or adjustment must be accessible. Items located above ceilings shall be located above accessible portions of the ceiling or above access panels provided by this Contractor. Manufactured items with internal components requiring access (whether integral with the enclosure or not) shall be provided with access panels. Access panels shall be provided in ductwork where required for maintenance or adjustment of internal components.

3.13 CONCRETE HOUSEKEEPING PADS:

A. Refer also to “Concrete” article in Part Two of this specification section.

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B. Concrete housekeeping pads shall be provided for all floor mounted mechanical equipment located in mechanical spaces. Where pads are shown on the drawings, they are representative only and do not necessarily indicate all locations where pads are required.

C. Pads shall be not less than 6" above the floor and shall extend not less than 6" beyond the equipment base in all directions, unless otherwise noted on the drawings.

D. Pads provided for air handling equipment shall be of sufficient height to allow for proper trap depth in the cooling coil condensate removal system.

3.14 SPARE FILTERS:

A. For all equipment provided with filters, this contractor shall provide spare filters to be installed after final acceptance of the systems. It is the responsibility of this contractor to install spare filters.

3.15 FIRE STOPPING:

A. All penetrations through fire-resistance-rated floor, fire resistance rated, floor/ceiling assemblies and roof construction and through fire-resistance-rated walls and partitions shall be fire stopped.

B. Penetrations to be fire stopped include both empty openings and those containing cables, pipes, ducts, conduits, and any other items.

C. Fire rating of sealed penetrations shall meet or exceed the rating of the assembly being penetrated.

D. Materials shall be installed in accordance with manufacturer's recommendations and their UL listing.

3.16 PREPARATION FOR TESTING AND BALANCING:

A. Review Contract Documents and submittals to verify that piping, instruments, thermowells, valves, ductwork, dampers, measurement and control devices, and access openings have been provided in correct quantity and at correct locations to permit testing and balancing of air and hydronic systems under various operating conditions.

B. Provide V-belt drives or variable pitch sheaves for fans as indicated. Provide variable frequency drives as Work of Division 26. Replace variable pitch sheaves or initial fixed pitch sheaves with appropriate fixed pitch sheaves when correct speed (rpm) has been determined by Testing and Balancing Agency. Deliver variable-pitch sheaves and initial fixed pitch sheaves to Owner's Representative. Notify TAB Agency upon completion of sheave replacement.

C. Inform TAB Agency regarding major deviations from Contract Documents made to systems during construction and furnish one (1) complete set of Record Drawings, showing presence and location of balancing elements, volume dampers, air extractors and instrument ports, prior to start of TAB work.

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D. Provide indicated Work and submit certification that each operation indicated is complete and in accordance with Contract Documents. Accomplish this Work before TAB work can start. Within 30 days of notification by Owner of award of Testing and Balancing Contract, submit schedule to complete following work:

1. Complete physical installation.
2. Pressure test air, and hydronic systems as required.
3. Clean, flush, fill and chemically treat hydronic systems as required. Provide temporary start-up strainers and replace with clean strainers after system cleaning as indicated.
4. Provide each air system with medium-efficiency disposable start-up filters. Replace filters one (1) time during construction. Replace with new specified filters upon acceptance of each system by Owner's Representative.
5. Test and operate prime movers, including fans, at full design load to verify adequate power, proper rotation, completed controls, operational auxiliaries, and complete overall installation.
6. Balance rotating equipment statically and dynamically.
7. Secure linkages.
8. Properly evacuate air from liquid systems. Install air vents at coils and at high points in systems whether or not expressly indicated and verify that they operate properly. Verify that expansion tanks are filled and in proper working order.
9. Verify that automatic control valves are in proper working order and location, that they are marked and installed with correct "NORMAL" positions as required, and that hand valves and balancing valves are positioned for full flow through equipment.
10. Verify that automatic control dampers are in proper working order and location, that they are marked and installed with "NORMAL" positions as required. Verify that balancing and shut-off dampers are positioned for full flow. Verify that equipment, terminal devices and distribution systems are completely and properly connected.

E. For each item of mechanical equipment, submit typed Data Register in non-yellowing, clear plastic binder, and securely attach it to associated equipment. Show operating temperature, pressure, flow rate, amperage, voltage, phase, frequency (Hz), rpm and brake horsepower {input power (kW), as appropriate.

F. Deliver to TAB Agency, for use until TAB work is complete, flow-indicating devices intended for use with permanently installed primary flow measuring devices. Calibrate permanently installed flow measuring devices and associated display instruments, thermometers, sensors and pressure gauges. Deliver documentation to TAB Agency to verify calibrations.

G. Submit schedule stating when each system is ready for TAB work to begin. Separate schedule by area, and mechanical system. Submit schedule within 30 days of Contract Award. Update schedule at least two (2) months in advance of scheduled start of TAB work.

H. Attend coordination meetings between TAB Agency, and Owner's Representative, conducted under guidance of Contractor. First meeting is approximately two (2) weeks before scheduled start of TAB work, as scheduled by Mechanical Contractor and approved by Owner's Representative.

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I. Provide labor, material, tools and equipment to operate mechanical equipment and systems during TAB work, and for required adjustments, calibrations and repairs of automatic control devices or their components. Provide these services on each working day and without undue delay, as required by TAB Agency. Protect and operate equipment and systems during TAB work.

J. When requested by TAB Agency, furnish services of personnel to accompany TAB Agency when TAB work is being performed.

K. Make modifications at no additional cost and to satisfaction of Owner's Representative to rectify discrepancies reported by TAB Agency indicating non-compliance with Contract Documents.

END OF SECTION 23 00 00

NOT FOR BIDDING PURPOSES

SECTION 23 00 05

COORDINATION DRAWING REQUIREMENTS FOR HVAC

PART 1 – GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 COORDINATION DRAWINGS

A. All mechanical, electrical, plumbing, fire protection, telecommunications, and ATC subcontractors will be required to use AutoCad (CAD) format. Coordination drawings will be distributed via email and/or USB drive.

1.3 ABOVE CEILING AND NO CEILING OVERHEAD INSTALLATION

A. The Mechanical Contractor shall furnish minimum 1/4" scale CAD electronic background drawings of the sheet-metal shop drawings, for incorporation of plumbing and mechanical piping services. All ductwork and piping systems shall be thoroughly dimensioned as to location and height above finished floor. Each different system will be drawn in a different color. Upon conclusion of the various systems coordination with the Sheet-Metal Contractor, the composite drawing shall be distributed by the Construction Manager for contractor coordination. All lighting fixture locations will be "ghosted in" by the Sheet-Metal Contractor for coordination of the same. The Sheet-Metal Contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the Sheet-Metal, HVAC Piping, Plumbing, Fire Protection, Electrical, Telecommunications and ATC firms, with the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."
>
> NOTE: The composite drawing is in addition to separate shop drawings to be submitted at the conclusion of the coordination process.

B. At the conclusion of each composite drawing coordination process, the Construction Manager shall be notified by the Mechanical Contractor Project Manager. The Mechanical Contractor Project Manager shall then schedule an on-site coordination meeting for the purpose of signing off on the respective drawing. The Mechanical Contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.

NOT FOR BIDDING PURPOSES

C. The Mechanical Contractor shall print a weekly status log and maintain a file for the project on this process. Each subcontractor is responsible to submit and coordinate their work with the Construction Manager and Mechanical Contractor.

D. The Fire Protection Contractor shall overlay their complete piping system on a composite background drawing furnished by the Mechanical Contractor. The Fire Protection Contractor shall utilize a different color from that previously used by the HVAC and Plumbing draftsmen. The Fire Protection Contractor shall cooperate in the coordination process by the relocation of their piping as required to facilitate coordination. When completed, Sprinkler Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the entire coordination process, the Fire Protection Contractor shall be responsible for attending a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signatures to the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."
>
> NOTE: The composite drawing is in addition to a separate sprinkler piping shop drawing to be submitted at the conclusion of the coordination process.

E. The Electrical Contractor shall be responsible to overlay their major conduit racks and equipment, as well as verifying all lighting fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. All conduits larger than 2" shall be documented. When completed, Electrical Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Electrical Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

F. The Plumbing Contractor will be responsible to overlay their major piping racks and equipment, as well as verifying all plumbing fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Plumbing Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Plumbing Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

G. The Telecommunication Contractor will be responsible to overlay their major communication racks and cable tray, as well as verifying locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed,

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Telecommunication Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Telecommunication Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

H. Provide survey and coordination of underground plumbing for verification of location.

I. Drawings, if available, may be obtained electronically from the Architect through the Construction Manager.

J. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall receive hard copies of all drawings.

K. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall review all drawings and advise if any additional drawings are needed.

L. The Mechanical Trade Contractor shall take the lead and develop a drawing list for submissions and a submission schedule coordinated with the construction activities. The drawings shall be developed in a sequential fashion so as to no delay installation of the work or the overall project schedule. The lead Mechanical trade contractor shall include a master key plan so that the area of each drawing can be readily identified as to the location within each building. The Plumbing trade contractor shall lead the underground coordination and the HVAC trade contractor shall lead the balance of the coordination work. The drawing list and schedule shall be forwarded to the Construction Manager for review.

M. Pursuant to Construction Manager approval of the list and schedule, the Mechanical trade contractor shall provide to all participants the latest plans in a timely fashion in accordance with their schedule.

N. Prior to the start of the work, each subcontractor shall forward an insulation schedule to the Construction Manager M.E.P. Coordinator. The schedule shall show the size and thickness of each type of insulation and its intended use.

1.4 SHEET-METAL / PIPING / ATC / ELECTRICAL ACCESS / MAINTENANCE CLEARANCES

A. As soon as practical, the Mechanical trade contractor shall prepare layout drawings (not less than 1/4" scale) of all ductwork and piping. These drawings shall show all WALL FIRE RATINGS, registers, grilles, diffusers and similar features, as well as locations of all valves, dampers, damper operators and other items requiring access for maintenance. It shall also be the responsibility of the Mechanical trade contractor to show on these drawings; beams with bottom elevations, ceiling heights, wall-to-wall dimensions, partitions, columns, windows, doors, electric lighting layouts as shown on the reflected ceiling plans, acoustical ceiling grid, and other major architectural and structural features as shown on the General Construction Drawings. All dimensions should be

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from centerlines of columns. All required access to equipment for service and/or required for NEC code required clearances shall be shown in a dotted zone.

B. The Mechanical trade contactor, upon completion of their work, shall email their data back to the Plumbing trade contractor and copy all participants. The Plumbing trade contractor shall download the mechanical data and incorporate, by separate layer, their own routing, as well as other areas requiring access for service and maintenance to determine their relationship and possible interferences with the mechanical, architectural, or structural features to be performed as part of the work.

C. The Plumbing trade contractor shall then email their data to the Electrical trade contractor and copy all participants. The Electrical trade contractor shall download the drawing and incorporate, by separate layer, their own routings, as well as the depth of all light fixtures, access panels, etc., as required to determine the relationship and possible interferences with plumbing, mechanical, architectural, or structural items to be installed as part of the overall work. The Electrical trade contractor shall be responsible to verify that the electrical lighting layout shown on these drawings is correct and to make corrections and additions of all other light fixtures as required. In areas where no mechanical work occurs, but where other crowded electrical installations are evident, the Electrical trade contractor shall prepare similar drawings.

D. The Electrical trade contractor shall then email the Fire Protection trade contractor and copy all participants. The Fire Protection trade contractor shall download the drawing and incorporate, by separate layer, their own routings, as well as other areas requiring access for service and maintenance, to determine their relationship and possible interferences with the mechanical, electrical, plumbing, and architectural or structural items to be installed as part of the overall work.

E. The Mechanical trade contractor shall provide one composite set of reproducible drawings and forward them to the Construction Manager. This composite shall then be reviewed during meetings determined by the Construction Manager, at which all subcontractors including their subcontractors, as required by the Construction Manager, shall be represented to review and resolve any real or apparent interference or conflicts.

F. In the preparation of all the final composite drawings, large scale details, as well as cross and longitudinal sections shall be made as required to fully delineate all conditions. Particular attention shall be given to the locations, size and clearance dimensions of equipment items, shafts and similar features. The final composite drawings shall include the locations of all controls, tie-ins, connections for other subcontractor's work, and pipe and duct insulation as required.

G. Final composite drawings shall then be signed off by each trade subcontractor indicating their acceptance and approval of the indicated routings and layouts and their relationship with the adjoining or contiguous work of all subcontracts. Thereafter, no unauthorized deviations shall be permitted. If deviations are made without the knowledge and agreement of Construction Manager and other affected trade contractors, the work in question shall be subject to removal and correction at no additional cost.

H. In preparing the composite drawings, minor changes in duct, pipe or conduit routings that do not affect the intended function may be made as required to avoid space conflicts, when mutually agreed. Items may not be resized, exposed items relocated, or items run exposed when not intended, without approval. No changes shall be made in any structural members or architectural

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features which affect the function or aesthetics of the buildings. If conflicts or interferences cannot be satisfactorily resolved, the Engineer shall be notified, and their decision obtained.

I. After final composite drawings have been accepted and approved, and signed by ALL subcontractors, the Mechanical trade contractor shall provide and distribute to each of the subcontractor and to Construction Manager. Subcontractors requiring further prints for their own distribution will accomplish same.

J. The record copies of final composite drawings shall be retained by each subcontractor as a working reference. All shop drawings, prior to their submittal to Construction Manager, shall be compared with the composite drawings and developed accordingly by the subcontractor responsible. Any revisions to the composite drawings, which may become necessary during the process of the work, shall be noted by all subcontractors and shall be neatly and accurately recorded on the record copies. Each trade contractor shall be responsible for the up-to-date maintenance of their own record copies of the composite drawings and to keep one copy available at the site. The composite drawings and any subsequent changes thereto, shall be utilized by each subcontractor in the development of their as-built drawings. NOTE: The coordination drawings may be used with appropriate changes as as-builts and changes to title block.

K. Preparation of coordination drawings shall commence as soon as possible after award of the subcontract. The coordination drawings may lack complete data in certain instances pending receipt of equipment drawings, but sufficient space shall be allotted for the items affected. When final information is received, such data shall be promptly inserted on the composite by that trade contractor.

L. Coordination is the responsibility of all trade contractors. Construction Manager will call meetings, weekly, or as required, which subcontractors must attend to avoid delay. Failure to attend shall require the trade contractor to field run the work not coordinated. No extra compensation will be paid to any trade contractor for relocating any duct, pipe, conduit or other material that has been installed without proper coordination. If the installation of any uncoordinated work or improper installation or coordinated work necessitates additional work by other subcontractors, at the cost of such additional work shall be assigned to the trade contractor responsible as determined by Construction Manager.

M. All changes in the work of any subcontract shall be shown on the composite drawings.

N. All work on the coordination composite drawings shall be performed by competent CAD operators, in a clear legible manner. Each trade contractor shall execute a typical drawing activity in no more than three working days. It shall be the responsibility of each subcontractor to supply a sufficient number of CAD operators so as not to delay the coordination process. Construction Manager and Engineer shall be the judge of the acceptability of the drawings.

O. The composite drawings shall not be used for as-built drawings. (See Paragraph above)

P. It shall be further understood that each trade contractor's specified submittals shall be transmitted for approval during the coordination period in order that the project encounter no delays.

Q. The Mechanical trade subcontractor shall pre-coordinate all control equipment locations with the designated ATC trade subcontractor and indicate it on the composite document.

NOT FOR BIDDING PURPOSES

1.5 REQUIREMENTS

A. All Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC trade contractors shall be required to use AutoCad (CAD) format. Coordination drawings shall be distributed via email or USB drive. ALL EMAILS SHALL BE COPIED TO CONSTRUCTION MANAGER, ENGINEER, AND PROJECT MANAGER.

B. The Sheet-Metal trade contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the sheet-metal, HVAC, piping, plumbing, sprinkler, electrical and ATC firms with the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

C. The Mechanical trade contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.

D. The Mechanical Contractor shall print a weekly status of all emails sent and received and maintain a hard copy file for use at the coordination "sign-off" meetings. Each subcontractor is required to check emails daily.

E. Submittals: Once the coordination process has been completed, the coordination drawings shall be submitted to the Engineer for review. A single-color plot, as well as three blueprint copies of the drawings shall be submitted for review. The color plot shall delineate between the various disciplines by utilizing different color pens for each system.

PART 2 – PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION (NOT APPLICABLE)

END OF SECTION 23 00 05

NOT FOR BIDDING PURPOSES

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.4 ACTION SUBMITTALS

A. Product Data:

1. Provide nameplate data including manufacturer, model, service factor, frame size, rpm, HP, voltage, phase, frequency, NEMA enclosure type, full load amperes, Design and Code letters, and insulation class.
2. Provide NEMA nominal and guaranteed minimum efficiencies and power factor at full load, weights and dimensions, UL listing where applicable, and bearing L10 life.
3. Certified sound-power ratings.

B. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in operation, and maintenance manuals.

NOT FOR BIDDING PURPOSES

1.7 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

C. Motors 1 hp and larger shall be premium efficiency.

D. Motors on equipment located outdoors shall be totally-enclosed, fan-cooled (TEFC) type. Motors on equipment located indoors shall be open drip-proof (ODP) or TEFC type unless otherwise noted.

E. Motors and drives shall not produce sound levels exceeding 90 dBA in accordance with Subpart G, Occupational Noise Exposure, of OSHA Standards. Sound measurement data shall be obtained in accordance with IEEE 85. Noise levels exceeding specified limit shall be clearly stated in Submittals.

F. Two-speed motors shall include separate windings.

G. 120 volt motors less than 1 hp shall include integral thermal overload protection with manual reset. If an integral overload is not available, format a motor rated toggle switch with thermal overload and provide to the electrical contractor for installation by electrical contractor.

H. Provide thermostats for hazardous duty and inverter duty motors, where required for warranty, to prevent overheating. Thermostat settings shall be 80 percent of temperature rating.

I. Motors 10 hp and higher shall include power factor correction to 95 percent, using either factory-installed and wired capacitors, or separately mounted and field-wired capacitors. Capacitors shall be UL-listed, non-PCB with self-healing dielectric film, pressure-sensitive interrupter, discharge resistors, grounding lug, and current-limiting protective fuses. Capacitors shall have 20-year nominal life, two (2) year special warranty, and shall be General Electric-Aerovox, Sprague, ABB, or Versatex. If correction devices are not so furnished, it shall be the responsibility of the Contractor furnishing the equipment to pay all wiring and installation costs.

J. For VFD motors, provide shaft mounted static discharge dissipation ring with conductive microfibers (Electro Static Technology AEGIS SGR or approved equal) to shunt bearing currents or provide electrically insulated ceramic bearings.

NOT FOR BIDDING PURPOSES

K. Motor Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. General Electric.
2. MagneTek.
3. Marathon.
4. Reliance.
5. Emerson Motors.
6. Baldor.
7. Toshiba.

L. Motor Base Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Korfund Dynamics Corp.
2. Mason Industries, Inc.
3. Consolidated Kinetics Corp.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Re-greaseable, shielded, antifriction ball bearings suitable for radial and thrust loading. Bearings for 460-volt motors: shielded, re-greaseable, vacuum degassed steel ball bearings sized for a minimum life (L-10) of 100,000 hours. Bearing housings shall be large enough to hold sufficient lubricant to minimize need for frequent lubrication. Provide extended grease tubes suitable for regreasing bearings in service.

NOT FOR BIDDING PURPOSES

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.6 MOTOR DRIVE AND BASES

A. Provide motors with Type A, B, C or D matched set V-belt drives or direct drives as indicated.

1. Drives shall be designed for 150 percent of specified motor nameplate horsepower rating.
2. Provide V-belts of endless cord impregnated rubber of trapezoidal cross-section.
3. Provide adjustable screw device for belt tensioning.
4. Drives shall include minimum of two (2) belts.

NOT FOR BIDDING PURPOSES

B. Provide variable-pitch motor sheaves for fans and other belt-driven equipment under 25 hp. Provide fixed-pitch "initial" motor sheaves for fans and other belt-driven equipment 25 hp and larger. Deliver variable and fixed pitch sheaves to Owner's Representative.

2.7 BELTS AND COUPLING GUARDS

A. Provide easily removable guards to completely enclose all V-belt drives, pulleys, sheaves and couplings.

B. Guards shall comply with requirements of Subpart O (Machinery and Machine Guarding) of referenced OSHA Standards.

C. Tachometers shall be readable with guards in place.

D. Where grease fittings are enclosed by guards, provide grease fitting extensions to accessible location outside of guard.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install Work in accordance with manufacturer's written instructions.

B. When not installed with driven equipment on a common base, install and align motors and drives.

C. Provide field wiring where separately mounted motor capacitors are used.

D. Provide control wiring from motor thermostats for hazardous duty and inverter duty motors to starter control circuit.

3.2 FIELD QUALITY CONTROL

A. Visually inspect motors for correct mounting, grounding, power connections and lubrication. Verify that thermostats, RTDs, and other auxiliaries are connected.

B. Megger test each 460-volt motor 40 hp and above using a 500 V dc test voltage and record the results. Minimum acceptable insulation resistance is 100 megohms. Test duration shall be one (1) minute except motors 200 hp and above shall be tested for ten (10) minutes. Calculate polarization index. Minimum acceptable polarization index is 2.0. Report and correct irregularities immediately.

C. Furnish calibrated instruments for testing motors.

D. Perform rotation test for proper shaft direction.

NOT FOR BIDDING PURPOSES

E. Prepare test and inspection reports.

END OF SECTION 23 05 13

NOT FOR BIDDING PURPOSES

SECTION 23 05 17

SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral water-stop unless otherwise indicated.

B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

2.2 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

NOT FOR BIDDING PURPOSES

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. HOLDRITE.

B. Description: Manufactured plastic, sleeve-type, water-stop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber water-stop collar with center opening to match piping OD.

2.4 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

NOT FOR BIDDING PURPOSES

C. Install sleeves in concrete floors, roof decks and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water-stop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

NOT FOR BIDDING PURPOSES

1. Exterior Concrete Walls above Grade:

    a. Piping Smaller Than NPS 4: Galvanized-steel-pipe sleeves.
    b. Piping NPS 4 and Larger: Galvanized-steel-pipe sleeves.

2. Concrete Slabs above Grade:

    a. Piping Smaller Than NPS 4: Galvanized-steel-pipe sleeves.
    b. Piping NPS 4 and Larger: Galvanized-steel-pipe sleeves.

3. Concrete Slabs above Grade (Mechanical equipment areas or other wet areas):

    a. Piping Smaller Than NPS 4: Galvanized-steel-pipe sleeves with sleeve-seal fittings.
    b. Piping NPS 4 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.

4. Interior Partitions:

    a. Piping Smaller Than NPS 4: Carbon-steel-pipe sleeves.
    b. Piping NPS 4 and Larger: Carbon-steel-pipe sleeves.

END OF SECTION 23 05 17

NOT FOR BIDDING PURPOSES

SECTION 23 05 18

ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

NOT FOR BIDDING PURPOSES

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Insulated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
f. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 23 05 18

NOT FOR BIDDING PURPOSES

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fastener systems.

B. Related Sections:

1. Section 230548 "Vibration Controls for HVAC" for vibration isolation devices.
2. Section 233113 "Metal Ducts" for duct hangers and supports.

1.4 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.5 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

NOT FOR BIDDING PURPOSES

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.7 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.8 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

NOT FOR BIDDING PURPOSES

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.4 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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C. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

D. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

E. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

F. Install lateral bracing with pipe hangers and supports to prevent swaying.

G. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

H. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

I. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

3.2 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

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3.3 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.4 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.5 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

G. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.

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3. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated, stationary pipes NPS 3/4 to NPS 8.
4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
5. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
6. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
7. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8.
8. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.
9. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
10. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
11. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
12. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
13. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
14. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
15. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
16. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
17. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
18. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

H. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

I. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

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3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

J. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.

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6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

L. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 23 05 29

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SECTION 23 05 48

VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient supports.
9. Resilient pipe guides.
10. Air-spring isolators.
11. Restrained-air-spring isolators.
12. Elastomeric hangers.
13. Spring hangers.
14. Vibration isolation equipment bases.
15. Restrained isolation roof-curb rails.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device type required.

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B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For each vibration isolation device.

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For testing agency.

C. Welding certificates.

D. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For [air-spring mounts] [and] [restrained-air-spring mounts] to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Ace Mountings Co., Inc.

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b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation.
h. Vibration Mountings & Controls, Inc.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient AND elastomeric.

a. Surface Pattern: Waffle pattern.
b. Infused nonwoven cotton or synthetic fibers.

2.2 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation.
h. Vibration Mountings & Controls, Inc.

2. Mounting Plates:

a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. Ace Mountings Co., Inc.
    b. California Dynamics Corporation.
    c. Isolation Technology, Inc.
    d. Kinetics Noise Control, Inc.
    e. Mason Industries, Inc.
    f. Vibration Eliminator Co., Inc.
    g. Vibration Isolation.
    h. Vibration Mountings & Controls, Inc.

2. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

    a. Housing: Cast-ductile iron or welded steel.
    b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. Ace Mountings Co., Inc.
    b. California Dynamics Corporation.
    c. Isolation Technology, Inc.
    d. Kinetics Noise Control, Inc.
    e. Mason Industries, Inc.
    f. Vibration Eliminator Co., Inc.
    g. Vibration Isolation.
    h. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

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2.5 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation.
h. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
b. Top housing with threaded mounting holes and internal leveling device elastomeric pad.

2.6 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation.
h. Vibration Mountings & Controls, Inc.

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

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a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
b. Top plate with threaded mounting holes elastomeric pad.
c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.7 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation.
h. Vibration Mountings & Controls, Inc.

2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.

a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

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2.8 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch-thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.9 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch-thick neoprene:

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.10 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.11 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

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a. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Kinetics Noise Control, Inc.
d. Mason Industries, Inc.
e. Vibration Eliminator Co., Inc.
f. Vibration Isolation.
g. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.12 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. California Dynamics Corporation.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. Vibration Eliminator Co., Inc.
5. Vibration Isolation.
6. Vibration Mountings & Controls, Inc.

B. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Rails shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.

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1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

2.13 RESTRAINED ISOLATION ROOF-CURB RAILS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Ace Mountings Co., Inc.
2. California Dynamics Corporation.
3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.
5. Thybar Corporation.

B. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment.

C. Upper Frame: Upper frame shall provide continuous and captive support for equipment.

D. Lower Support Assembly: The lower support assembly shall be formed sheet metal section containing adjustable and removable steel springs that support upper frame. The lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials and shall be insulated with a minimum of 2 inches of rigid glass-fiber insulation on inside of assembly. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 VIBRATION CONTROL DEVICE INSTALLATION

A. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

END OF SECTION 23 05 48

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SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Pipe labels.
3. Duct labels.
4. Stencils.
5. Valve tags.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

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PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

   a. Brady Corporation.
   b. Brimar Industries, Inc.
   c. Carlton Industries, LP.
   d. Champion America.
   e. Craftmark Pipe Markers.
   f. emedco.
   g. Kolbi Pipe Marker Co.
   h. LEM Products Inc.
   i. Marking Services, Inc.
   j. Seton Identification Products.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
3. Letter Color: Black.
4. Background Color: White.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/2 inch. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
2. Brady Corporation.

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3. Brimar Industries, Inc.
4. Carlton Industries, LP.
5. Champion America.
6. Craftmark Pipe Markers.
7. emedco.
8. Kolbi Pipe Marker Co.
9. LEM Products Inc.
10. Marking Sevices Inc.
11. Seton Identification Products.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch.

2.3 DUCT LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark Pipe Markers.
6. emedco.
7. Kolbi Pipe Marker Co.
8. LEM Products Inc.
9. Marking Sevices Inc.
10. Seton Identification Products.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black

D. Background Color: Blue.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

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F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.4 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
2. Brady Corporation.
3. Brimar Industries, Inc.
4. Carlton Industries, LP.
5. Champion America.
6. Craftmark Pipe Markers.
7. emedco.
8. Kolbi Pipe Marker Co.
9. LEM Products Inc.
10. Marking Sevices Inc.
11. Seton Identification Products.

B. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain or beaded chain.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

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PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Pipe Label Color Schedule:

1. Natural Gas Piping: White letters on a safety-yellow background.
2. Refrigerant Piping: White letters on a safety-green background.

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3. Condensate drain Piping: White letters on a safety-green background.

3.5 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Green: For exhaust, outside, relief and return.

B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

a. Refrigerant: 2 inches, round.
b. Gas: 2 inches, round.

END OF SECTION 23 05 53

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SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. Balancing Air Systems:
    a. Constant-volume air systems.
2. Testing, Adjusting, and Balancing Equipment:
    a. Heat-transfer coils.
3. Duct leakage tests.
4. Control system verification.

1.4 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. TAB: Testing, adjusting, and balancing.

D. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

E. TDH: Total dynamic head.

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1.5 PREINSTALLATION MEETINGS

A. TAB Conference: Conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.6 ACTION SUBMITTALS

A. LEED Submittals:

1. Air-Balance Report for Prerequisite IEQ 1: Documentation indicating that work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
2. TAB Report for Prerequisite EA 2: Documentation indicating that work complies with ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.

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3. Application.
4. Dates of use.
5. Dates of calibration.

1.8 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.9 FIELD CONDITIONS

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

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E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible, and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine operating safety interlocks and controls on HVAC equipment.

O. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

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B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete, and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

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C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.

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4. Obtain approval from Engineer of Record for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.6 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record fan and motor operating data.

3.7 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.

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2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.8 DUCT LEAKAGE TESTS

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.9 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.10 TOLERANCES

A. Set HVAC system's airflow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus, or minus 10 percent.
2. Air Outlets and Inlets: Plus, or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.11 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC

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systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.12 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.

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15. Test conditions for fans performance forms including the following:

    a. Settings for outdoor, return, and exhaust air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Settings for supply-air, static-pressure controller.
    g. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Duct, outlet, and inlet sizes.
3. Pipe and valve sizes and locations.
4. Terminal units.
5. Balancing stations.
6. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Center-to-center dimensions of sheave and amount of adjustments in inches.
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.

2. Motor Data:

    a. Motor make, and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm.
    b. Total system static pressure in inches wg.
    c. Fan rpm.

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d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Cooling-coil static-pressure differential in inches wg.
g. Heating-coil static-pressure differential in inches wg.
h. Outdoor airflow in cfm.
i. Return airflow in cfm.
j. Outdoor-air damper position.
k. Return-air damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft.
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Refrigerant expansion valve and refrigerant types.
i. Refrigerant suction pressure in psig.
j. Refrigerant suction temperature in deg F.
k. Inlet steam pressure in psig.

G. Gas Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.

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h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

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a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

I. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft.
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

J. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

K. System-Coil Reports: For reheat coils of terminal units, include the following:

1. Unit Data:

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a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.

L. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.13 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of commissioning authority.

B. Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
3. If the second verification also fails, design professional may contact AABC Headquarters regarding the AABC National Performance Guaranty.

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F. Prepare test and inspection reports.

3.14 ADDITIONAL TESTS

A. Within 30 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 05 93

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SECTION 23 07 13

DUCT INSULATION

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed outdoor air.
3. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
4. Indoor, concealed oven and ware wash exhaust.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, exposed supply and return.

B. Related Sections:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.

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3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.
5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.8 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

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1.9 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge or expanded rubber materials. Comply with ASTM C 534, Type II for sheet materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Aeroflex USA, Inc.
b. Armacell LLC.
c. K-Flex USA.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. CertainTeed Corporation.
b. Johns Manville; a Berkshire Hathaway company.
c. Knauf Insulation.
d. Manson Insulation Inc.
e. Owens Corning.

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H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. CertainTeed Corporation.
b. Johns Manville; a Berkshire Hathaway company.
c. Knauf Insulation.
d. Manson Insulation Inc.
e. Owens Corning.

I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory applied ASJ jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. CertainTeed Corporation.
b. Johns Manville; a Berkshire Hathaway company.
c. Knauf Insulation.
d. Manson Insulation Inc.
e. Owens Corning.

J. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Armacell LLC.
b. Nomaco Insulation.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C 656, Type II, Grade 6. Tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

a. Johns Manville; a Berkshire Hathaway company.

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B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. 3M.
b. CertainTeed Corporation.
c. Johns Manville; a Berkshire Hathaway company.
d. Nelson Firestop; a brand of Emerson Industrial Automation.
e. Thermal Ceramics.
f. Unifrax Corporation.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Aeroflex USA, Inc.
b. Armacell LLC.
c. Foster Brand; H. B. Fuller Construction Products.
d. K-Flex USA.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.
d. Mon-Eco Industries, Inc.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.
d. Mon-Eco Industries, Inc.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Dow Corning Corporation.
b. Johns Manville; a Berkshire Hathaway company.
c. P.I.C. Plastics, Inc.
d. Speedline Corporation.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Knauf Insulation.
d. Vimasco Corporation.

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2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.
   d. Knauf Insulation.
   e. Mon-Eco Industries, Inc.
   f. Vimasco Corporation.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Vimasco Corporation.

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3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.
   d. Mon-Eco Industries, Inc.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

   a. Childers Brand; H. B. Fuller Construction Products.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

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1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

a. Childers Brand; H. B. Fuller Construction Products.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Foster Brand; H. B. Fuller Construction Products.
b. Vimasco Corporation.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

a. Alpha Associates, Inc.

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

NOT FOR BIDDING PURPOSES

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. Johns Manville; a Berkshire Hathaway company.
    b. P.I.C. Plastics, Inc.
    c. Proto Corporation.
    d. Speedline Corporation.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.

D. Metal Jacket:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. RPR Products, Inc.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

    a. Sheet and roll stock ready for shop or field sizing.
    b. Finish and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper.
    d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.

E. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross laminated polyethylene film covered with **white** aluminum-foil facing.

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

    a. Polyguard Products, Inc.

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. Avery Dennison Corporation, Specialty Tapes Division.
    b. Compac Corporation.
    c. Ideal Tape Co., Inc., an American Biltrite Company.

NOT FOR BIDDING PURPOSES

d. Knauf Insulation.
e. Venture Tape.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Avery Dennison Corporation, Specialty Tapes Division.
b. Compac Corporation.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.
e. Venture Tape.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Compac Corporation.
b. Ideal Tape Co., Inc., an American Biltrite Company.
c. Venture Tape.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Avery Dennison Corporation, Specialty Tapes Division.

NOT FOR BIDDING PURPOSES

b. Compac Corporation.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.
e. Venture Tape.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. ITW Insulation Systems; Illinois Tool Works, Inc.
b. RPR Products, Inc.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch-thick, 1/2 inch wide with wing seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch-thick, 1/2 inch wide with wing seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1) AGM Industries, Inc.
2) Gemco.
3) Hardcast, Inc.
4) Midwest Fasteners, Inc.
5) Nelson Stud Welding.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

NOT FOR BIDDING PURPOSES

1) AGM Industries, Inc.
2) CL WARD & Family Inc.
3) Gemco.
4) Hardcast, Inc.
5) Midwest Fasteners, Inc.
6) Nelson Stud Welding.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

      1) AGM Industries, Inc.
      2) Gemco.
      3) Midwest Fasteners, Inc.

   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch-thick by 2 inches square.
   c. Spindle: Copper or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

      1) Gemco.
      2) Midwest Fasteners, Inc.

   b. Baseplate: Perforated, nylon sheet, 0.030 inch-thick by 1-1/2 inches in diameter.
   c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

NOT FOR BIDDING PURPOSES

1) AGM Industries, Inc.
2) Gemco.
3) Hardcast, Inc.
4) Midwest Fasteners, Inc.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch-thick by 2 inches square.
c. Spindle: Copper or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1) AGM Industries, Inc.
2) Gemco.
3) Hardcast, Inc.
4) Midwest Fasteners, Inc.
5) Nelson Stud Welding.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1) Gemco.
2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, galvanized steel.

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

a. C & F Wire.

2.13 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

NOT FOR BIDDING PURPOSES

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces, free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

NOT FOR BIDDING PURPOSES

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

NOT FOR BIDDING PURPOSES

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements Comply with requirements in architectural section of the specifications.
2. firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in architectural section of the specifications.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

NOT FOR BIDDING PURPOSES

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not over compress insulation during installation.
e. Impale insulation over pins and attach speed washers.
f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

NOT FOR BIDDING PURPOSES

b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not over compress insulation during installation.
e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

NOT FOR BIDDING PURPOSES

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in architectural sections of the specification.

3.9 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in architectural sections of the specifications.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

NOT FOR BIDDING PURPOSES

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location for each duct system defined in the "Duct Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed outdoor air.
3. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
4. Indoor, concealed oven and ware wash exhaust.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, exposed supply and return.

B. Items Not Insulated:

1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Factory-insulated access panels and doors.

3.12 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round, supply-air duct insulation shall be of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

B. Concealed, round, outdoor-air duct insulation, except for DOAS unit outside air, shall be of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

C. Concealed, rectangular, supply-air and kitchen make-up duct insulation shall be of the following:

1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

D. Concealed, rectangular, return-air duct insulation shall be of the following:

1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

E. Concealed, rectangular, outdoor-air duct insulation shall be of the following:

NOT FOR BIDDING PURPOSES

1. Mineral-Fiber Blanket: 2 inches thick and 3-lb/cu. ft. nominal density.

F. Concealed, rectangular, exhaust-air duct insulation, except DOAS unit exhaust air, between isolation damper and penetration of building exterior shall be of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

G. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.

H. Concealed, supply-air plenum insulation shall be of the following:

1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

I. Concealed, outdoor-air plenum insulation shall be of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

J. Concealed, exhaust-air plenum insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

K. Exposed, rectangular, outdoor-air duct insulation shall be of the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

L. Exposed, rectangular, exhaust-air duct insulation shall be of the following:

1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

M. Exposed, outdoor-air plenum insulation shall be of the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

N. Exposed, exhaust-air plenum insulation shall be of the following:

1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed:

NOT FOR BIDDING PURPOSES

1. None.
2. PVC: 30 mils thick.

END OF SECTION 23 07 13

NOT FOR BIDDING PURPOSES

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NOT FOR BIDDING PURPOSES

SECTION 23 07 19

HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Condensate drain piping, indoors.
2. Refrigerant suction and hot-gas piping, indoors and outdoors.

B. Related Sections:

1. Section 230713 "Duct Insulation."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.
8. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

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1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.8 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

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1.9 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Aeroflex USA, Inc.
b. Airex Manufacturing.
c. Armacell LLC.
d. K-Flex USA.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

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a. Aeroflex USA, Inc.
b. Armacell LLC.
c. Foster Brand; H. B. Fuller Construction Products.
d. K-Flex USA.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Knauf Insulation.
d. Vimasco Corporation.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

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2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
c. Vimasco Corporation.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.5 SEALANTS

A. Joint Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.
d. Mon-Eco Industries, Inc.
e. Pittsburgh Corning Corporation.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.
d. Mon-Eco Industries, Inc.

3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 deg F.
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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B. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Childers Brand; H. B. Fuller Construction Products.
b. Eagle Bridges - Marathon Industries.
c. Foster Brand; H. B. Fuller Construction Products.
d. Mon-Eco Industries, Inc.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Johns Manville; a Berkshire Hathaway company.
b. P.I.C. Plastics, Inc.
c. Proto Corporation.
d. Speedline Corporation.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

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a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

D. Metal Jacket:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. ITW Insulation Systems; Illinois Tool Works, Inc.
b. RPR Products, Inc.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross laminated polyethylene film covered with white aluminum-foil facing.

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal :

a. Polyguard Products, Inc.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. Avery Dennison Corporation, Specialty Tapes Division.
    b. Compac Corporation.
    c. Ideal Tape Co., Inc., an American Biltrite Company.
    d. Knauf Insulation.
    e. Venture Tape.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.9 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. RPR Products, Inc.

2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch-thick, 1/2 inch wide with closed seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, galvanized steel.

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

    a. C & F Wire.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

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J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

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3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in architectural sections of the specifications for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in architectural sections of the specifications.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, and Unions:

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1. Install insulation over fittings and unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
5. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
6. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

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3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

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1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints, for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of brazed and soldered fittings for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.11 INDOOR PIPING INSULATION SCHEDULE

A. Condensate Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be the following:

a. Flexible Elastomeric: 3/4 inch thick.

B. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be the following:

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a. Flexible Elastomeric: 1 inch thick.

C. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be the following:

a. Flexible Elastomeric: 1 inch thick.

D. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be the following:

a. Flexible Elastomeric: 2 inches thick.

E. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be the following:

a. Flexible Elastomeric: 2 inches thick.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Exposed:

1. Painted Aluminum, Smooth: 0.016 inch thick.

3.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Exposed:

1. Aluminum, Corrugated with Z-Shaped Locking Seam: 0.020 inch thick.

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SECTION 23 08 00

COMMISSIONING OF MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including General and Supplementary Conditions and other Division 1 specification sections, apply to this section.

B. ASHRAE Standard 202

C. Commissioning Plan

D. Related sections include the following:

1. Section 01 33 00 Submittal Procedures
2. Section 01 42 00 References
3. Section 01 78 23 Operations and Maintenance Data
4. Section 01 78 39 Project Record Documents
5. Section 01 79 00 Demonstration and Training
6. Section 01 91 13 General Commissioning Requirements
7. Division 22 requirements for work in those Sections
8. Section 22 08 00 Commissioning of Plumbing Systems
9. Division 23 requirements for work in those Sections
10. Section 23 08 00 Commissioning of Mechanical Systems
11. Section 26 08 00 Commissioning of Electrical Systems
12. Division 28 requirements for work in those sections

1.2 SUMMARY

A. This section includes general requirements that apply to the implementation of the commissioning process without regard to specific systems, assemblies, and components.

B. The commissioning process does not remove or reduce the responsibility of the Contractor to provide a finished and fully functioning product. Commissioning should not add to the overall work effort. Commissioning puts a focus on following standard installation and startup procedures, documenting them, resolving issues in a timely manner, verifying the Owner's Project Requirements through equipment, system, and integrated system testing, to permit a smooth turnover and acceptance at the end of the project.

1.3 DESCRIPTION

A. Commissioning: Commissioning is a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meet defined objectives and criteria. The Commissioning process begins at project inception (during the pre-

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design phase) and continues through the life of the facility. The commissioning process includes specific tasks to be conducted during each phase in order to verify that design, construction, and training meets the owner's project requirements.

B. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:

1. Verify that applicable equipment and systems are installed according to the contract documents, manufacturer's recommendations, and industry accepted minimum standards and those they receive adequate operational checkout by installing contractors.
2. Verify and document proper performance of equipment and systems.
3. Verify that O&M documentation left on site is complete.
4. Verify that the owner's operating personnel are adequately trained.

1.4 COORDINATION

A. Coordinate all sub-trades, other divisions, manufacturers, suppliers, and other specialists as required to ensure all phases of work shall be properly organized prior to commencement of each particular startup, testing and commissioning procedure.

B. Coordinate the activities of this Section with the Commissioning requirements of:

1. Division 1
2. Division 22
3. Division 23
4. Division 26
5. Other equipment and systems testing specified in this and other Divisions.

C. Where any equipment or systems require testing prior to starting, ensure that such work has been completed and approved prior to starting of the equipment and or systems.

1.5 RESPONSIBILITIES

A. The Mechanical Commissioning process for the vendors/subcontractors consists of:

1. Facilitate the coordination of commissioning and provide to the General Contractor (GC) commissioning activities for incorporation into the Overall Project Schedule (OPS).
2. Provide detailed startup procedures.
3. Include the cost of commissioning in the total contract price.
4. Ensure that all subcontractors and vendors execute their commissioning responsibilities according to the contract documents and the OPS.
5. Provide copies of all submittals as required in Section 013300 including all changes thereto.
6. Attend and participate in commissioning team meetings held as necessary throughout the construction and acceptance phases.
7. Provide the training of owner personnel.
8. Review and perform Pre-Functional Checklists (PFC) provided by the CxP.
9. Provide test reports as required by Division 21, 22, and 23 to the CxP for review.

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10. Cooperate with the CxP for resolution of issues recorded in the Issues Log.
11. Perform work associated with deficiencies identified on the Issues Log and during Functional Performance Testing.
12. Prepare O&M manuals, according to the contract documents, including clarifying and updating the original sequences of operation to as-built/as-tested conditions.
13. Provide assistance for seasonal or deferred performance testing.
14. Ensure that subcontractors correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
15. Perform all guarantees work for materials furnished under the contract for the time specified in the contract, including all warranties, and curing all latent defects within the time period provided in the contract.

1.6 SUBMITTALS

A. Refer also to Specification Section 01 91 13, Subsection 1.8.

B. Provide to the Commissioning Agent (CxP) one (1) approved copy of the following per section 01 91 13:

1. Product Data and Shop Drawings
2. Operations and Maintenance Data, including sequence of operations.
3. Manufacturer's Reports:
4. Arrange for manufacturer to submit copies of all production test records required by these specifications prior to shipping.
5. The production test records will be certified by the manufacturer, that the item meets the testing performance criteria specified.
6. Contractor test reports
7. Manufacturer equipment startup reports
8. Testing, Adjusting, and Balancing (TAB) reports.
9. Test equipment calibration certificates.
10. Completed pre-functional checklists to be submitted prior to functional performance testing.

1.7 EQUIPMENT/SYSTEMS TO BE COMMISSIONED

A. The mechanical systems to be commissioned are listed in the Commissioning Plan with roles and responsibilities listed in Part 3 of 23 08 00.

1.8 QUALITY ASSURANCE

A. Test Equipment Calibration: Comply with test equipment manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately whenever instruments have been repaired following damage or dropping. Affix calibration tags to test instruments. Instruments shall have been calibrated within six months prior to use.

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PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Provide two-way radios, ladders and other equipment as required to complete the commissioning program as outlined in this specification.

B. Provide all safety equipment required for personnel involved in the Commissioning program.

C. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division.

D. All test and measurement instruments shall have been calibrated within the calendar year prior to testing by an independent metrology laboratory using industry standards and methods.

PART 3 – EXECUTION

3.1 MEETINGS

A. Attend as required by section 01 91 13, Subsection 3.1.

3.2 STARTUP, CONSTRUCTION CHECKLISTS, AND INITIAL CHECKOUT

A. Provide as required by section 01 91 13.

B. The subcontractors and vendors shall execute startup and provide the CxP and A/E, through the owner, with a signed and dated copy of the completed startup and construction checklists.

C. Only individuals of the subcontractor (technicians, engineers, tradesmen, vendors, etc.) who have direct knowledge and witnessed that a line-item task on the construction checklist was actually performed shall check off that item. It is acceptable for witnessing supervisors to fill out these forms.

3.3 FUNCTIONAL PERFORMANCE TESTING

A. Provide as required by section 01 91 13.

B. All subcontractor and manufacturer startup and proving tests are to be completed and approved prior to conducting the defined Functional Performance Tests.

C. All associated TAB work and TAB verifications related to a given system shall be completed and approved prior to Functional Performance Testing.

D. All associated Building Management System (BMS) work and BMS point verifications related to a given system shall be completed and approved prior to Functional Performance Testing for related equipment and systems.

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3.4 DEFICIENCIES AND NON-CONFORMANCE

A. Provide as required by section 01 91 13.

3.5 DEFERRED TESTING

A. Provide as required by section 01 91 13.

3.6 TRAINING OF OWNER PERSONNEL

A. Provide training for hardware and major components as specified within Section 01 91 13, 01 79 00, Divisions 22, 23, 26 and in the Commissioning Plan.

B. Coordinate operation and maintenance training activities through the GC.

C. The subcontractor and manufacturers shall provide training. The training sessions provided by the subcontractor shall be customized for this project and reflect all the installed equipment and systems. Training of the materials, components, systems, and equipment shall, at the minimum, incorporate the following items:

1. Materials, components, systems, and equipment
2. Safety precautions and procedures
3. Installation
4. Operational features and functions
5. Operational testing and diagnostics
6. Preventive and predictive maintenance
7. Service: Repair and replacement
8. Operation and Maintenance manual content
9. Testing, adjusting, calibration and balancing.
10. Contractor furnished spare parts and extra materials.
11. Recommended “attic stock” inventory not furnished by contractor.
12. Specialty tool requirements
13. Identification systems
14. Automatic/manual control systems
15. Hazards/Material Safety Data Sheets
16. Cleaning
17. Procurement of replacement parts
18. Warranty reviews including terms and conditions, points of contact, return material procedures, effective date, extended warranty options.
19. Maintenance agreements and similar continuing commitments
20. Reference specification section 01 79 00 for specific requirements.

D. No later than two (2) months following acceptance of equipment and system submittals, the responsible Contractor will submit written training plans to the CxP and Owner for review and approval. There shall be one training plan for each specification section requiring training.

E. Provide Training Plans for all equipment as required in the Division 23 contract specifications.

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F. Submit the roster and the completed training plans to the CxP through the GC no later than one (1) week following acceptable completion of the training session.

3.7 OPERATIONS AND MAINTENANCE MANUALS

A. Provide operations and maintenance manuals for hardware and major components as specified within Section 01 78 23, 01 91 13, Divisions 22, 23, 26 and in the Commissioning Plan.

B. Coordinate operation and maintenance submittals through the GC.

C. CxP Review and Approval. Prior to substantial completion, the CxP shall review the operations and maintenance manuals, documentation and redline as-builts for systems that were commissioned to verify compliance with the specifications. The CxP will communicate deficiencies in the manuals to the owner. This work does not supersede the A/E team's review of the operations and maintenance manuals according to the A/E contract.

END OF SECTION 23 08 00

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SECTION 23 09 10

INSTRUMENTATION AND CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. This Section specifies minimum requirements for all instrumentation and control equipment and shall be fully coordinated and integrated with Division 23 and 26 sections. Provide instrumentation and control equipment, submit documentation including equipment catalogs, calibrate, test, place in service, and supply spare parts and associated labor for first year of operation for instrumentation and controls required for mechanical and electrical equipment and systems provided in accordance with Contract Documents.

B. Related Requirements:

1. Section 230923 "Direct Digital Control System for HVAC" for equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls".

1.4 DEFINITIONS

A. BAS: Building Automation System.

B. BMS: Building Monitoring System.

C. DDC: Direct-digital control.

D. Ethernet: Local area network based on IEEE 802.3.1 standards.

E. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

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F. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

G. I/O: Input/output

H. NBR: Nitrile butadiene rubber.

I. PTFE: Polytetrafluoroethylene

J. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

K. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

L. RS-485: A TIA standard for multipoint communications using two twisted pairs.

M. RTD: Resistance temperature detector.

N. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.

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5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Delegated-Design Submittal:

1. Schedule and design calculations for control actuators, including the following:

a. Flow at project design and minimum flow conditions.
b. Damper face velocity at project design and minimum airflow condition.
c. Pressure drop across each damper and flow sensor at project design and minimum flow condition.
d. Maximum close-off pressure.
e. Leakage flow at maximum system pressure differential.
f. Torque required at worst case condition for sizing actuator.
g. Actuator selection indicating torque provided.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Control damper installation location shown in relationship to room, duct, pipe, and equipment.
2. Size and location of wall access panels for control dampers installed behind walls.
3. Size and location of ceiling access panels for control dampers installed above inaccessible ceilings.
4. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.

B. Product Certificates: For each product indicated requiring a certificate.

C. Product Test Reports: For each product indicated, for tests performed by a qualified testing agency.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control valves to include in operation and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Retain paragraph below for product parts inventory over extended operating period.

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C. Provide parts, as indicated by manufacturer's recommended parts list, for product operation during one-year period following warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Delegated Design: Engage a qualified professional, to size products where indicated as delegated design.

D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

E. Control Dampers:

1. Dampers shall have stable operation throughout full range of operation, from design to minimum airflow over varying pressures and temperatures encountered.
2. Control dampers shall be full size of duct or equipment connection unless otherwise indications.

F. Air sensors and transmitters shall have an extended range of 20 percent above Project design flow and 20 percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

G. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

    a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated and cooled, filtered, and ventilated as required by instrument and application.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures.

2.2 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

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1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
3. Damper actuator shall be factory installed by damper manufacturer as integral part of damper assembly. Coordinate actuator location and mounting requirements with damper manufacturer.

B. Rectangular Dampers with Aluminum Airfoil Blades:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

   a. Ruskin Company.

2. Performance:

   a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
   b. Pressure Drop: 0.05-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
   c. Velocity: Up to 6000 fpm.
   d. Temperature: Minus 40 to plus 185 deg F.
   e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
   f. Damper shall have AMCA seal for both air leakage and air performance.

3. Construction:

   a. Frame:

      1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles,0.07 inch thick.
      2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
      3) Width not less than 5 inches.

   b. Blades:

      1) Hollow, airfoil, extruded aluminum.
      2) Parallel or opposed blade configuration as required by application.
      3) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.07 inch thick.
      4) Width not to exceed 6 inches.
      5) Length as required by close-off pressure, not to exceed 48 inches.

   c. Seals:

      1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
      2) Jambs: Stainless steel, compression type.

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d. Axles: 0.5-inch-diameter plated steel, mechanically attached to blades.
e. Bearings:

1) Molded synthetic or stainless-steel sleeve mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and plated steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

2.3 ROUND CONTROL DAMPERS

A. Round Dampers, Sleeve Type:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

a. Ruskin Company.

2. Performance:

a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
b. Pressure Drop: 0.02-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 25 to plus 200 deg F.
e. Pressure Rating: Equal to or greater than pressure rating of ductwork, but minimum of 8-in. wg for sizes through 12 inches, and minimum of 6-in. wg for larger sizes.

3. Construction:

a. Frame:

1) Material: Galvanized steel, 0.04 in thick.

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2) Outward rolled stiffener beads positioned approximately 1 inch inboard of each end.
3) Sleeve-type connection for mating to adjacent ductwork.
4) Size Range: 4 to 24 inches.
5) Length not less than 7 inches.
6) Provide 2-inch sheet metal stand-off for mounting actuator.

b. Blade: Double-thickness circular flat blades sandwiched together and constructed of galvanized steel.
c. Blade Seal: Polyethylene foam seal sandwiched between two sides of blades and fully encompassing blade edge.
d. Axle: 0.5-inch-diameter plated steel, mechanically attached to blade.
e. Bearings: Stainless-steel sleeve pressed into frame.

2.4 ELECTRONIC CONTROL DAMPER ACTUATORS

A. Actuators shall operate related dampers with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off or open against the maximum system pressures encountered. Actuators shall be sized to close off or open against the shutoff pressure as a minimum requirement.

C. Position indicator and graduated scale on each actuator.

D. Type: Motor operated, with or without gears, electric and electronic.

E. Voltage: 24-V ac.

F. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

G. Function properly within a range of 85 to 120 percent of nameplate voltage.

H. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

I. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

J. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

K. Provide mounting hardware and linkages for connecting actuator to damper.

L. Select actuators to fail in desired position in the event of a power failure.

M. Construction:

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1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

N. Field Adjustment:

1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

O. Two-Position Actuators: Single direction, spring return or reversing type.

P. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range and starting in either direction from any point in range.
2. Control Input Signal:

    a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
    b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for V dc 4- to 20-mA signals.
    c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
    d. Programmable Multi-Function:

        1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
        2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
        3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

Q. Position Feedback:

1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Equip modulating actuators with position feedback through current signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

R. Fail-Safe:

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1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

S. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

T. Damper Attachment:

1. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

U. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

V. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.

W. Stroke Time:

1. Operate damper from fully closed to fully open within 15 seconds.
2. Operate damper from fully open to fully closed within 15 seconds.
3. Move damper to failed position within 15 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems shall comply with governing code and NFPA requirements.

X. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

2.5 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:

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1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

    a. Range: Minus 50 to 275 deg F.
    b. Interchangeable Accuracy: At 32 deg F within 0.5 deg F.
    c. Repeatability: Within 0.5 deg F.
    d. Self-Heating: Negligible.

4. Transmitter Requirements:

    a. Transmitter required for each 100-ohm RTD.
    b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

    a. Minco.

2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F.
4. Probe: Single-point sensor with a stainless-steel sheath.
5. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch

C. Platinum RTD, Air Temperature Averaging Sensors:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

    a. Minco.

2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F.
4. Multiple sensors to provide average temperature across entire length of sensor.
5. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
6. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
7. Length: As required by application to cover entire cross section of air tunnel.
8. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
9. Gasket for attachment to duct or equipment to seal penetration airtight.
10. Conduit Connection: 1/2-inch

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D. Platinum RTD Outdoor Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

   a. Minco.

2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F.
4. Probe: Single-point sensor with a stainless-steel sheath.
5. Solar Shield: Stainless steel.
6. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
7. Conduit Connection: 1/2-inch trade size.

E. Platinum RTD Space Air Temperature Sensors:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

   a. Minco.

2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 212 deg F.
4. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover.
5. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
6. Concealed wiring connection.

2.6 COMBINATION AIR TEMPERATURE SENSOR AND SWITCH

A. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

1. Minco.

B. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

C. Combination temperature sensor and switch in same instrument.

D. Air Temperature Switch:

1. Factory preset set point of 38 deg F. Field-adjustable set point from 30 to 44 deg F.
2. Responsive to coldest 12-inch section of sensor length.
3. DPST latching relay rated at 25 A and 120-V ac, with powered controller, coil, and manual rest at panel. Wire one leg to fan start circuit and other leg to signal a remote alarm.

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E. Air Temperature Sensor:

1. Temperature-averaging type over sensor length. Length to be determined by installing trade to provide uniform coverage over air tunnel. Consult manufacturer for recommendations.
2. Platinum RTD with a value of 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
3. Accuracy: Within 0.9 deg F.
4. Output Signal: 4 to 20 mA for connection to remote monitoring.
5. Encase RTDs in a flexible nominal 0.375-inch-diameter sheath constructed of brass.
6. Lead wires shall be 18-gage AWG copper.
7. Enclosure: NEMA 250, Type 4.

2.7 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Honeywell International Inc.
   b. Siemens Building Technologies, Inc.

2. Description:

   a. Two-position control.
   b. Field-adjustable set point.
   c. Manual reset.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:

   a. Operating Temperature Range: 15 to 55 deg F.
   b. Temperature Differential: 5 deg F, non-adjustable and additive.
   c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
   d. Sensing Element Maximum Temperature: 250 deg F.
   e. Voltage: 120-V ac.
   f. Current: 16 FLA.
   g. Switch Type: Two SPDT snap switches operate on coldest 12-inchsection along element length.

4. Construction:

   a. Vapor-Filled Sensing Element: Nominal 20 feetlong.
   b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
   c. Set-Point Adjustment: Screw.
   d. Enclosure: Painted metal, NEMA 250, Type 1.
   e. Electrical Connections: Screw terminals.
   f. Conduit Connection: 1/2-inch trade size.

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2.8 AIR TEMPERATURE RTD TRANSMITTERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

1. Minco.

B. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

C. House electronics in NEMA 250 enclosure.

1. Duct: Type 1.
2. Outdoor: Type 4.
3. Space: Type 1.

D. Conduit Connection: 1/2-inch

E. Functional Characteristics:

1. Input:

a. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
b. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.

2. Span (Adjustable):

a. Space: 40 to 90 deg F.
b. Supply Air Cooling and Heating: 40 to 120 deg F.
c. Supply Air Cooling Only: 40 to 90 deg F.
d. Supply Air Heating Only: 40 to 120 deg F.
e. Return Air: 50 to 100 deg F.
f. Mixed Air: Minus 40 to 140 deg F.
g. Outdoor: Minus 40 to 140 deg F.

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
5. Match sensor with temperature transmitter and factory calibrate together.

F. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

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2.9 MOISTURE SENSORS AND TRANSMITTERS

A. Sensors and Transmitters with Digital Display:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

a. Vaisala.

2. Performance:

a. Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 2.5 percent from 90 to 100 percent relative humidity when operating between 60 to 77 deg F.
b. Relative Humidity Range: Zero to 100 percent.
c. Factory calibrated and NIST traceable with certificate included.

3. Construction:

a. Provide housing with integral sensor for room applications.
b. Provide housing with remote sensor probe for ducted applications.

1) Duct Sensor Body: 300 series stainless steel or chrome-plated aluminum, at least 2 inches long for duct-mounted applications.
2) Provide sensor with cable for field installation in conduit.
3) For duct-mounted applications, thread the sensor assembly for connection to a threaded mounting flange.

c. Provide general-purpose humidity sensor unless application requires special requirements. Provide sensor with sintered stainless-steel filter for duct applications.
d. Housing shall be ABS/PC plastic or powder-coated aluminum.
e. Housing Classification: NEMA 250, Type 4 or 4X.
f. Provide housing with wall-mounting plate.

4. Output Signal: 2-wire, 4- to 20-mA output signal with a drive capacity of at least 500 ohms at 24-V dc.
5. Provide unit with a digital display of relative humidity in percent.

B. Sensor and Transmitter without Display:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

a. Vaisala.

2. Performance:

a. Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 3 percent from 90 to 95 percent relative humidity when operating at 68 deg F.

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b. Relative Humidity Range:

1) Duct: Zero to 100 percent.
2) Space: Zero to 95 percent relative.

c. Factory calibrated and NIST traceable with certificate included.

3. Construction for Space Applications:

a. Housing with integral sensor.
b. Housing shall be ABS plastic or powder-coated aluminum.
c. Enclosure: NEMA 250, Type 4.
d. Provide housing with a wall-mounting plate.

4. Construction for Duct and Equipment Applications:

a. Housing with integral sensor.
b. Duct Sensor Body: 300 series stainless steel.
c. Provide sensor with sintered stainless-steel filter for duct applications.
d. Housing shall be cast aluminum.
e. Enclosure: NEMA 250, Type 4.

5. Output Signal: Two-wire, 4- to 20-mA output signal with drive capacity of at least 500 ohms at 24-V dc.

2.10 COMBINATION HUMIDITY AND TEMPERATURE SENSOR AND TRANSMITTER WITH DISPLAY:

A. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

1. Vaisala.

B. Description:

1. Factory package consisting of humidity and temperature sensor, digital display, keypad user interface, installation hardware, interconnecting sensor cabling, installation instructions, and operating manual.
2. Each transmitter shall be individually calibrated and provided with NIST traceable calibration certifications.
3. Provide a service cable for connecting to a notebook computer and Microsoft Windows compatible software.

C. Display:

1. Alphanumeric display of the following on the face of the enclosure:

a. Percent relative humidity.
b. Absolute humidity.
c. Mixing ratio.

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d. Dry-bulb temperature.
e. Wet-bulb temperature.
f. Dew point temperature.
g. Enthalpy.

2. Visual display of measurement trends, and minimum and maximum values over a one-year period.

D. Electronics Enclosure:

1. Integral to sensors for wall- (room-)mounted applications and remote from temperature and humidity sensors for duct and equipment applications.
2. NEMA 250, Type 4 or 4X.
3. Labeled terminal strip for field wiring connections.

E. Output Signals:

1. Three Analog Outputs: 4 to 20 mA.

F. Temperature Sensor:

1. Temperature range matched to application, but not less than minus 40 to 140 deg F.
2. Within 0.5 deg F accuracy over the temperature range of 50 to 100 deg F and within 1 deg F over the remainder of the range.
3. Provide duct installation kit for duct applications.

G. Humidity Sensor:

1. Relative Humidity Measurement Range: Zero to 100 percent.
2. Response time in still air within 40 seconds.
3. Accuracy including non-linearity, hysteresis, and repeatability:

a. For Temperature between Minus 4 and 104 Deg F: Within 1 percent plus 0.008 times relative humidity reading.

4. Sintered, stainless-steel filter, protecting sensor.
5. Provide duct installation kit for duct applications.

H. Power Supply:

1. Field Power: 24-V ac, unless otherwise required by the application.
2. Internal Power: As required by transmitter.

2.11 AIR-PRESSURE SENSORS

A. Duct Traverse Static Pressure Sensor:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

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a. Air Monitor Corporation.

2. Sensor shall traverse the duct cross section and have at least one pickup point every 6 inches along length of sensor.
3. Construct sensor of 18-gage Type T6063-T5 extruded and anodized aluminum.
4. Sensor supported with threaded rod, sealing washer, and nut at one end and a mounting plate with gasket at other end.
5. Mounting plate with threaded, NPS 3/8 compression fitting for connection to tubing.
6. Accuracy within 1 percent of actual operating static pressure.
7. Dual offset static sensor design shall provide accurate sensing of duct static pressure in the presence of turbulent and rotational airflows with a maximum 30-degree yaw and pitch.
8. Suitable for velocities of 100 to 10000 fpm and temperatures of up to 200 deg F.
9. Sensor air resistance shall be less than 0.1 times the velocity pressure at probe-operating velocity.
10. Suitable for flat oval, rectangular, and round duct configurations.

B. Space Static Pressure Sensor for Wall Mounting:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

a. Air Monitor Corporation.

2. Aluminum wall plate with perforated center arranged to sense space static pressure. Exposed surfaces are provided with brush finish.
3. Wall plate provided with screws and sized to fit standard single-gang electrical box.
4. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch fitting for tubing connection.
5. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.

C. Space Static Pressure Sensor for Recessed Ceiling Mounting:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

a. Air Monitor Corporation.

2. Aluminum round plate with perforated center arranged to sense space static pressure. Exposed surfaces provided with brush finish.
3. Sensor intended for flush mount on face of ceiling with pressure chamber recessed in ceiling plenum.
4. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch fitting for concealed tubing connection.
5. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.

D. Space Static Pressure Sensor for Exposed or Suspended Mounting:

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1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

    a. Air Monitor Corporation.

2. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.
3. Aluminum with perforations arranged to sense space static pressure. Exposed surfaces provided with brush finish.
4. Sensor fitted with multiple sensing ports, pressure impulse suppression chamber, and airflow shielding.
5. Surface-mounted sensor provided with solid mounting plate intended for mount to ceiling with pressure chamber exposed to view.
6. Surface-mounted sensor with 0.125-inch fitting for exposed tubing connection.
7. Suspended sensor intended for pendent mount with pressure chamber exposed to view.
8. Suspended sensor with NPS 1/2 fitting for exposed pipe or tubing connection.

2.12 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

    a. Dwyer Instruments, Inc.

2. Diaphragm operated to actuate an SPDT snap switch.

    a. Fan safety shutdown applications: Switch with manual reset.

3. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
4. Enclosure Conduit Connection: Knock out or threaded connection.
5. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
6. High and Low Process Connections: Threaded, NPS 1/8.
7. Enclosure:

    a. Dry Indoor Installations: NEMA 250, Type 1.
    b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
    c. Hazardous Environments: Explosion proof.

8. Operating Data:

    a. Electrical Rating: 15 A at 120- to 480-V ac.
    b. Pressure Limits:

        1) Continuous: 45 inches wg.
        2) Surge: 10 psig.

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c. Temperature Limits: Minus 30 to 180 deg F.
d. Operating Range: Approximately 2 times set-point.
e. Repeatability: Within 3 percent.
f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.13 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

a. Ashcroft Inc.

2. Performance:

a. Range: Approximately 2 times set point.
b. Accuracy: Within 1 percent of the full-scale range.
c. Hysteresis: Within 0.10 percent of full scale.
d. Repeatability: Within 0.05 percent of full scale.
e. Stability: Within 1 percent of span per year.
f. Overpressure: 10 psig.
g. Temperature Limits: Zero to 150 deg F.
h. Compensate Temperature Limits: 40 to 150 deg F.
i. Thermal Effects: 0.033 percent of full scale per degree F.
j. Shock and vibration shall not harm the transmitter.

3. Output Signals:

a. Analog Current Signal:

1) Two-wire, 4- to 20-mA dc current source.
2) Signal capable of operating into 800-ohm load.

4. Display: Four-digit digital display with minimum 0.4-inch-high numeric characters.
5. Operator Interface: Zero and span adjustments located behind cover.
6. Construction:

a. Plastic casing with removable plastic cover.
b. Threaded, NPS 1/4 swivel fittings for connection to copper tubing or NPS 3/16 barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
c. Screw terminal block for wire connections.
d. Vertical plane mounting.
e. NEMA 250, Type 4.
f. Provide mounting bracket suitable for installation.

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2.14 POSITION LIMIT SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

1. OMRON Corporation.

B. Description: Select type of actuating head (plunger, roller lever, or rod) to suit application.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Performance:

1. Life expectancy: Not less than 30 million mechanical operations and 750,000 electrical operations.
2. Operating Frequency: 300 mechanical operations per minute and 30 electrical operations per minute.
3. Voltage: 120-, and 480- V ac or 24- V dc, as required by application.
4. Current Rating: As required by application.
5. Temperature Rise: 50 deg C.
6. Ambient Temperature: 14 to 175 deg F.
7. Ambient Relative Humidity: 35 to 95 percent.

D. Construction:

1. NEMA 250, Type 4X enclosure.
2. Switch Type: SPDT or DPDT, as required by application.
3. Status indicator integral to switch. Field switchable to light when contacts are actuated and operating, or contacts are free and not operating.
4. Electrical Connection: Screw or plug-in terminals.
5. Conduit Connection: NPS 1/2.

2.15 LEAK DETECTION SWITCHES

A. Point-Type, Leak-Detection Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Veris Industries.
b. W. E. Anderson; Dwyer Instruments, Inc.

B. Requirements in remaining subparagraphs are based on W. E. Anderson's "Series WD2."

1. Features: Audible and visual alarm with relay output for remote indication.
2. Alarm activated based on change in resistance.
3. Performance:

a. Service: Water.

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b. Temperature Limits: 32 to 122 deg F.
c. Switch Type: SPDT relay.
d. Electric Connection: Cable attached.

4. Construction: Acrylic, ABS plastic.
5. Field Power: 24-V ac or dc.

C. Cable-Type, Leak-Detection Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

a. W. E. Anderson; Dwyer Instruments, Inc.

D. Requirements in remaining subparagraphs are based on W. E. Anderson's "Series WD" or approved equal:

1. Control Module Features:

a. Power and alarm LEDs.
b. Alarm test switch.
c. Continuous tape integrity self check.

2. Performance:

a. Service: Water, or other conductive liquid.
b. Switch Type: DPDT.
c. Electric Connection: Screw terminals.
d. Conduit Connection: 0.5 inch.

3. Construction:

a. Control Module Enclosure: Extruded aluminum.
b. Tape: Hydrophobic with connector on each end.
c. Tape Length: As required for application. Field extendable.

4. Field Power: 24-V ac or V dc.

2.16 CARBON DIOXIDE (CO2) SENSORS

A. CO^2 sensor shall be either wall or duct mounted as shown in the design and shall utilize a non-dispersive infrared (NDIR) sensing method to provide a direct readout of CO^2 levels over range of 0 to 2000 ppm. Sensor shall provide a linear output signal that can be linked to BCS.

B. CO^2 sensor shall have the following characteristics:

1. Gas Detected: Carbon Dioxide (CO^2).
2. Sensing Method: Single-beam, non-dispersive infrared (NDIR).
3. Measurement Range: 0 to 2000 ppm.
4. Accuracy: Plus, or minus 5 percent of reading and plus or minus 50 ppm at 77 degrees F.

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5. Max Annual Drift: 20 ppm (nominal).
6. Repeatability: Plus, or minus 20 ppm.
7. Output Drift: Maximum 2 percent of full range.
8. Operating Range:

    a. Humidity: 5 to 95 percent RH, non-condensing.
    b. Temperature: 32 to 104 degrees F.

9. Output Signal:

    a. Current: 4 to 20 mA dc.

10. Response Time: 1 minute to 90 percent of step change.
11. Calibration:

    a. Adjustment: Zero and span.
    b. Interval: By usage, one (1) year maximum recommended.

12. Mounting: Space or duct as required.

C. Approved Manufacturer:

1. Vaisala.
2. GE Sensing TelAire.
3. Honeywell.
4. Johnson Controls.
5. Siemens.
6. BAPI.
7. Approved equal

2.17 LOCAL UNIT CONTROL PANELS

A. Panels shall be NEMA 1 (if located indoors) or NEMA 4 (if located outdoors) enclosures at least 24 inches wide, 12 inches high and a minimum of 8 inches deep or 6 inches deep in finished spaces, with a locking door. Total panel, including removable backplate for equipment mounting, shall be made rust-resistant and painted with epoxy enamel. All door locks shall operate from a common key.

B. Each item of terminal equipment (for example, dampers) controlled from panel-mounted devices shall be provided with a flush-mounted panel-door air gage at least 2 inches in diameter.

C. Provide separate temperature gages for all duct-mounted sensors located as indicted and, as a minimum, shall include mixed-air, discharge-air and return-air ducts, and ducts downstream of preheat coils. Gages shall be a minimum of 2 1/2 inches in diameter with plus or minus 1 percent full-scale accuracy.

D. Gages and control devices of fan system shall be placed in one (1) group for each system on a hinged control panel door so that complete operation of all equipment can be checked simultaneously at panel. Piping shall be inside panel.

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E. Manually-operated switches, gradual switches and pilot lights shall be door mounted.

F. Provide lamacoid nameplates, with 3/16-inch engraved black letters on white background, permanently secured in place describing panel device. Clearly identify items as to function, switch position, temperature, location, and type of temperature controller. Use of plastic tape is acceptable.

G. Other control devices shall be located inside panel and mounted to allow sufficient space for both interconnecting wiring. Interior panel wiring shall be arranged in a systematic, orderly manner and brought to terminal blocks for connection of field wiring. Low-voltage and line-voltage terminals shall be isolated from each other.

H. Furnish Record Drawings in a plastic pocket affixed inside panel to show systems and devices controlled from panel.

2.18 WEATHERSHIELDS

A. Provide appropriate weather housings for temperature and Relative Humidity sensors installed outdoors.

B. Housings shall prevent sun from directly striking sensors and shall not radiate to sensors. Provide adequate ventilation so that sensor responds to ambient environmental conditions of surrounding.

C. Shields shall be compatible with surface on which they are installed. Housings shall be as indicated.

2.19 CONTROL RELAYS

A. Control relays shall be of electro-mechanical type with coils for 120 V ac, 60 Hz power, and shall have contacts suitable for required load without contact bounce.

B. Relays shall have normally open (N. O.) and normally closed (N.C) contacts, as required, with quantity of poles required to perform indicated functions.

C. Approved Manufacturers:

1. Ptter-Brumfield.
2. Agastat.
3. Magnecraft.
4. IDEC.
5. Approved equal

2.20 INSTRUMENTATION CABLE

A. Cable shall be designed for transmitting a two-wire current signal over required distance.

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B. Cable shall contain two (2) conductors, 7 strands each, 100 percent shielded in an aluminum-polyester foil shield, and one (1) stranded conductor drain wire. Conductors shall be NO. 18 AWG wire covered with minimum 15 mil thick fire-retardant PVC insulation. Drain wire shall be No. 20 AWG. All wires shall be encased in a minimum 35 mil thick fire-retardant PVC jacket.

C. Cable shall be UL listed PLTC for 300-volt operation.

D. Approved Manufacturers:

1. Belden.
2. Alpha.
3. Dekron
4. Approved equal

2.21 PLENUM CABLE

A. In areas served by mechanical ventilation or air handling systems where space above ceiling acts as an air plenum and local codes permit, provide plenum cable specifically formulated and manufactured for low-smoke and low-flame spread classification in place of other insulated wire in conduit, if desired.

B. Power-limited circuit cable (CLZP) shall be UL listed for Class 2 circuits installed as wiring within plenum of a building, shall be resistant to spread of fire, shall have low smoke characteristics, and shall have been subjected to and passed UL 910.

C. Paragraph 727-38b (3) of NFPA 70 shall apply.

D. Cable can be installed without conduit in plenums.

E. Acceptable conductor insulation types are:

1. Teflon FEP (Fluorinated ethylene propylene).
2. Halar E-CTFE (Ethylene chlorotrifluoroethylene).
3. Kynar PVDF (Polyvinylidene fluoride).

F. Acceptable manufacturers are:

1. Dekoron by Fluorocarbon/Samuel Moore Group.
2. Alpha Wire Corporation.
3. Ausimont USA, Inc.
4. Belden Wire and Cable.
5. Approved equal

2.22 WIRING AND TERMINALS

A. Electrical wiring within equipment cabinets shall be neatly arranged in Panduit, properly supported, and terminated on one (1) side of terminal blocks only so that external connections

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for control, instrumentation, and auxiliary power can be made to other side of terminal blocks inside each equipment cabinet. Instrument connections shall be protected in a NEMA 1 enclosure, unless in a damp or wet location, in which a NEMA 4 enclosure shall be used in accordance with NEPA 70. No connections shall be exposed.

B. At least 20 percent spare unused terminals shall be provided in each group of terminal blocks. Control circuits and power circuits shall be completely separated by use of divided or separate terminal blocks. Terminal blocks for external connections shall be General Electric, Weidmuller, Phoenix Contact, Woertz, or approved equal designed to accommodate up to No. 12 AWG cable. No more than 2 wires shall be connected to anyone (1) terminal block screw. Wire connections shall be made with horseshoe or ring-tongue compression terminals unless terminal block is specifically designed for bare wire connection. Stranded wire shall connect to terminal block with insulated ferrules. Label terminal blocks and each device termination.

2.23 CURRENT TRANSFORMERS

A. Provide a donut-type current transformer with a 0 to 5 ampere ac output.

B. Current transformer shall be compatible with current transducers specified below.

2.24 CURRENT TRANSDUCERS

A. Current transducer shall accept standard 0 to 5 amps ac input (150 V ac maximum) from a current transformer (CT). Input signal isolation shall be provided by a single-turn primary input transformer. Overload capability shall be 35 amps for 30 seconds.

B. Unit output shall be a 4 to 20 mA dc signal (or other standard process current or voltage signal compatible with BCS) proportional to input current.

C. Unit shall be powered from a 120 V ac, 60 Hz source. (Units requiring dc voltages shall be provided with 120 v ac/0 to 60 V dc power supply).

D. Unit shall have an adjustable zero and span, with ripple less than 10 mV P/P maximum span and load.

E. Approved Manufacturers:

1. Moore Industries, Inc.
2. DEVAR, Inc., Control Products Division.
3. Rochester Instrument System (with dc power supply).
4. Neilson-Kuljian.
5. Approved equal

2.25 CURRENT-SENSING RELAYS

A. Current-sensing relays shall provide a normally open contact rated at a minimum of 50 volts peak and 1/2 ampere or 25 VA, non-inductive.

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B. There shall be a single hole for passage of current-carrying conductors.

C. Devices shall be sized for operation at 50 percent rated current based on connected load.

D. Voltage isolation shall be a minimum of 600 volts.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping and ductwork to verify actual locations of piping connections before installation.

C. Confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.
2. Do not begin installation without submittal approval of mounting location.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support dampers, actuators, instruments, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.

F. Fastening Hardware:

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1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

I. Provide required control and interlock wiring, including smoke detectors, fire alarms (other than power), fan interlocks, control panels, and other devices for a complete and operable system, and as described System Sequences of Operation.

J. Provide pilot-duty relays as required for interlocking of equipment as described in Sequences of Operation.

K. Verify quantity and size of wiring required for systems.

L. If a field-mounted device or piece of equipment requires 120 V ac service and is mounted at a difference location from 120 Vac power source provided under Electrical: Division 26, provide extensions to power wiring, including conduit, junction boxes, and other hardware, in accordance with Electrical: Division 26. This requirement shall also apply to devices powered by 24 V or greater.

M. Thermostats, temperature sensors, humidistats and humidity sensors located on exterior walls shall be mounted on back-insulated blocks.

N. Provide wiring for smoke detectors into control circuit of fans.

O. Demonstrate to Owner’s Representative that field wiring is installed in accordance with Electrical: Division 26 and is properly connected to appropriate device(s) as indicated and as described in Building Control System Sequences of Operation.

P. Provide, at each duct thermostat and temperature sensor and where else indicated, direct-reading duct thermometers that are readable by a person standing on floor so that thermostat/sensor operation can be checked.

Q. Install control panels so that they are stable and fully supported. Locate panels a minimum of 1 inch from wall.

R. Air handling unit duct smoke detectors will be furnished under Electrical: Division 26 and mounted under Duct Accessories: Division 23. Conduit and wiring from each duct smoke detector to individual fan starter will be provided under Electrical: Division 26. Provide all final connections at fan starter for each air handling unit as indicated. Final connections at duct smoke detector end will be normally closed contacts and will be made under Electrical: Division 26.

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S. Power wiring to control panels, will be provided under Electrical: Division 26.

T. Provide labor for coordination and preparation during testing and balancing of systems as performed under Testing and Balancing of Mechanical System.

U. If control panels are placed at locations different from those indicated, extend related accessories, including housekeeping pads and power wiring, and other tubing and wiring, to new locations and make required connections required at new locations. Provide additional electrical wiring and related equipment other than that provided under Electrical: Division 26 in accordance with System manufacturer's written recommended instructions.

V. If more control panels than those indicated are required, indicated requirements shall apply to additional panels.

W. Control panels are indicted on HVAC plans for approximate location and space allocation only and are not indicated dimensionally or quantitatively. Total quantity of control panels required shall be determined by actual point capacities and spare point requirements as indicated. Provide related accessories, including extension of housekeeping pads, and power wiring to additional control panels.

X. Provide required cooperation and coordination with Electrical: Division 26 such that power and ground wiring is provided in accordance with DDC System equipment manufacturer's written recommendations. DDC System supplier/installer shall make final electrical connections to DDC System equipment.

Y. Coordinate with Electrical: Division 26 and associated Electrical Contract Documents to verify which items of DDC System Equipment require un-interruptible power supply (UPS) power. Provide individual and total DDC System equipment KVA load to Electrical: Division 26 in order to ensure proper UPS and feeder capacity. Provide air compressor motor load data to Electrical Installer for coordination of feeder capacity.

Z. For NEMA 12 cabinets, provide electrical isolation between cooling fan and thermostat and electronics in cabinet such that cooling fan operation does not affect FEP operation. Provide means to drain cooling equipment condensate without piping along floors, walkways or exits.

AA. At penetrations through designated vapor-retardant walls, as indicated on Architectural Drawings, provide patching and sealant with silicone sealant in accordance with Division 7. Also provide air and vapor tight sealing of shielded air probes (SAPs) with silicone sealant.

BB. Temperature:

1. RTDs: RTDs may be used in ducts or spaces. When installed in airstreams or spaces, RTDs shall be rigidly supported. RTDs used for space-temperature sensing shall include a housing suitable for wall mounting. RTDs used for outside-air sensing shall have an instrument shall have an instrument shelter to minimize solar effects and shall be mounted to isolate building thermal effects. RTD assemblies shall be readily accessible and installed in such a manner as to allow for easy replacement. Sensors located outdoors shall be NEMA 4 rated.

CC. Humidity:

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1. Relative Humidity: Provide air guards/sintered filters when there are air flows greater than 50 fpm across sensor element. Sensors located outdoors shall be NEMA 4 rated.

DD. Test field equipment in conjunction with Building Control System (BCS).

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 GROUNDING

A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 15 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches f clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuators to damper drive shaft.

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F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.6 TEMPERATURE, RELATIVE HUMIDITY AND PRESSURE INSTRUMENT INSTALLATIONS

A. Mounting Location:

1. Roughing In:

a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
2) Do not begin installation without submittal approval of mounting location.

c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

2. Install switches and transmitters associated with individual air-handling units and connected ductwork and piping in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
3. Install switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Mount switches and transmitters on walls. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
2. Instruments having performance impacted by temperature and relative humidity of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

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a. Make every effort to mount at 60 inches.

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Space Sensor Installation:

1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
3. In finished areas, recess electrical box within wall.
4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Outdoor Air Sensor Installation:

1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.
3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

G. Single-Point Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Low-Limit Air Temperature Switch Installation:

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1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

J. Duct Pressure Sensors:

1. Install sensors using manufacturer's recommended upstream and downstream distances.
2. Unless indicated on Drawings, locate sensors approximately 67 percent of distance of longest hydraulic run. Location of sensors shall be submitted and approved before installation.
3. Install mounting hardware and gaskets to make sensor installation airtight.
4. Route tubing from the sensor to transmitter.
5. Use compression fittings at terminations.
6. Install sensor in accordance with manufacturer's instructions.
7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

K. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 50 feet; otherwise, locate switch in vicinity of system connection.

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

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B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.9 CHECKOUT PROCEDURES

A. Instrumentation Checkout: Perform the following for all instruments including control dampers:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check each instrument for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Control-Damper Checkout:

1. Verify that control dampers are installed correctly for flow direction.
2. Verify that proper blade alignment, either parallel or opposed, has been provided.
3. Verify that damper frame attachment is properly secured and sealed.
4. Verify that damper actuator and linkage attachment are secure.
5. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
6. Verify that damper blade travel is unobstructed.

C. Temperature and Humidity Instrument Checkout:

1. Verify sensing element type and proper material.
2. Verify location and length.
3. Verify that wiring is correct and secure.

D. Flow Instrument Checkout

E. Verify that sensors are installed correctly with respect to flow direction.

F. Verify that sensor attachment is properly secured and sealed.

G. Verify that processing tubing attachment is secure.

H. Inspect instrument tag against approved submittal.

I. Verify that recommended upstream and downstream distances have been maintained.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

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2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

G. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.

H. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

I. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

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3.11 MAINTENANCE AND SERVICE

A. General Requirements: Provide services, and provide materials, and equipment required for successful operation of entire system and appurtenances for a period of one (1) year after Date of Acceptance by Owner and Design Professional. System acceptance shall be defined as full completion of testing and performance verified by Owner's Representative and sign-off of acceptance.

B. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of systems and equipment Installer. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

C. Emergency Service: Supplier/Installer furnish services of a Technical Representative capable of servicing equipment at Project Site before end of working day when service call is made prior to noon. Supplier/Installer furnish services of a Technical Representative capable of servicing equipment at Project Site before noon of next working day when service call is made after noon or during evening or weekend.

D. Personnel: Advise Owner's Representative in writing of names of designated service representative and of service personnel. Update this list when there are changes in personnel.

1. Supervision: During maintenance and service, furnish services of a supervisor with full authority to act for Supplier/Installer. Supervisor shall effect daily liaison during normal working hours with Owner.
2. Service Personnel: Provide qualified service personnel to adjust and repair system.

E. Service Contract: Submit, ninety (90) days prior to expiration of Warranty Period, at time of initial bid proposal, a two (2) year extended Service Contract Proposal, which may be accepted by Owner up to end of first year Warranty Period.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

END OF SECTION 23 09 10

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SECTION 23 09 10.14

FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

PART 2 - PRODUCTS

A. Performance Requirements:

1. Adjustable for changes in system operational parameters.
2. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.

    a. Product certificates are required.

B. Thermal Airflow Station:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Ebtron, Inc. or approved equal.

2. Source Limitations: Obtain airflow and temperature measuring sensors and transmitters from single manufacturer.
3. Description: Airflow station shall consist of one or more sensor probes mounted in a casing, and a remotely mounted microprocessor-based transmitter.
4. Performance:

    a. Capable of independently processing up to 16 independently wired sensor assemblies.
    b. Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
    c. Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output.
    d. Listed and labeled by an NRTL as successfully tested as an assembly according to UL 873, "Temperature-Indicating and Regulating Equipment."
    e. Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-listed cable placed in conduit.
    f. Airflow Accuracy: Within 2 percent of reading over the entire operating airflow range.

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1) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets the performance requirements throughout the measurement range.

g. Temperature Accuracy: Within 0.2 deg F over entire operating range of minus 20 to plus 140 deg F.
h. Sensor Ambient Operating Temperature Range: Minus 20 to plus 160 deg F.
i. Transmitter Ambient Operating Temperature Range: Minus 20 to plus 120 deg F.
j. Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, non-condensing.
k. Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.
l. Pressure Drop: 0.05-inch wg at 2000 fpm across a 24-by-24-inch area.
m. Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than 0.5 percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan in order to deliver Project design airflow indicated.

5. Sensor Assemblies:

a. Each sensor probe shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
b. Mount thermistors in sensor using a marine-grade, waterproof epoxy.
c. Thermistor leads shall be protected and not exposed to the environment.
d. Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.
e. Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.
f. Sensor Probe Material: Gold anodized, extruded 6063 aluminum tube or Type 304 stainless steel.
g. Probe Assembly Mounting Brackets Material: Type 304 stainless steel.

6. Casing:

a. Factory mount sensor probes in an airflow station casing to create a single assembly for field mounting.
b. Material: Galvanized sheet steel at least 0.079 inch-thick with coating complying with ASTM A 653/A 653M, G90. Casings shall be stainless steel, 0.0781 inch-thick, when connected to stainless duct and aluminum, 0.063 inch thick, when connected to aluminum duct.
c. Joints and Seams: Continuously weld. Clean galvanized areas damaged by welding and coat with zinc-rich paint.
d. Casing Depth: At least 8 inches.
e. Include casing inlet and discharge connections with connection flanges.

7. Transmitter:

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a. Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
b. Capable of field configuration and diagnostics using an onboard push-button interface and digital display.

1) Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:

a) Integral protection from transients and power surges.
b) Circuitry to ensure reset after power disruption, transients, and brownouts.
c) Integral transformer to convert field power source to operating voltage required by instrument.

c. Remote Signal Interface:

1) Linear Analog Signals for Airflow and Temperature: Fuse protected and isolated, 4 to 20 mA.
2) BACnet Ethernet, BACnet-IP

2.2 AIRFLOW SWITCHES

A. Polymer Film Sail Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Honeywell International Inc or approved equal.

2. Performance:

a. Suitable for applications operating at velocities up to 400 fpm.
b. Suitable for mounting with air direction in horizontal, vertical up or down.
c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
d. Voltage: 24 V ac.
e. Normally open switch actuates at 250 fpm and opens at 75 fpm.
f. Normally closed switch actuates at 75 fpm and closes at 250 fpm.
g. Maximum Process Temperature: 170 deg F.
h. Maximum Ambient Temperature: 125 deg F.

3. Construction:

a. Polyester film sail encasing a wire frame.
b. Sail actuates a SPDT snap switch.
c. Enclosure Material: Zinc-plated steel.
d. Enclosure with removable cover.
e. NEMA 250, Type 1 enclosure.

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f. Removable spring counterbalances sail to allow mounting in either vertical (up or down) or horizontal airflow.
g. Electrical Connections: Screw terminals.
h. Conduit Connections: 1/2-inch trade size conduit knock outs on top and bottom.

2.3 AIRFLOW TRANSMITTERS

A. Airflow Transmitters with 0.25 Percent Accuracy and Auto-Zero Feature:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Air Monitor Corporation or approved equal.

2. Transmitter shall receive total- and static-pressure signals from a flow element, amplify signals, extract the square foot, and scale the signals to produce 4- to 20-mA dc output signals linear to airflow.
3. NEMA 250, Type 1 enclosure.
4. Construct assembly so shock, vibration, and pressures surges of up to 1 psig will neither harm transmitter, nor affect its accuracy.
5. Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. The automatic zeroing circuit shall re-zero the transmitter to within 0.1 percent of true zero.
6. Performance:

   a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
   b. Calibrated Span: Field adjustable, minus 40 percent of the range.
   c. Accuracy: Within 0.25 percent of natural span.
   d. Repeatability: Within 0.15 percent of calibrated span.
   e. Linearity: Within 0.2 percent of calibrated span.
   f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.

7. Integral digital display for continuous indication of airflow.

B. Pressure Differential Transmitters for Airflow Measurement:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Setra System or approved equal.

2. Performance:

   a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
   b. Accuracy: Within 0.5 percent of the full-scale range.
   c. Hysteresis: Within 0.10 percent of full scale.
   d. Repeatability: Within 0.05 percent of full scale.
   e. Stability: Within one percent of span per year.

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f. Overpressure: 10 psig.
g. Temperature Limits: Zero to 150 deg F.
h. Compensate Temperature Limits: 40 to 150 deg F.
i. Thermal Effects: 0.033 percent of full scale per degree F.
j. Shock and vibration shall not harm the transmitter.

3. Output Signals:

a. Analog Current Signal:

1) Two-wire, 4- to 20-mA dc current source.
2) Signal capable of operating into 800-ohm load.

4. Display: Four-digit digital with minimum 0.4-inch-high numeric characters.
5. Operator Interface:

a. Zero and span adjustments located behind cover.

6. Construction:

a. Plastic casing with removable plastic cover.
b. Fittings: Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
c. Screw terminal block for wire connections.
d. Vertical plane mounting.
e. NEMA 250, Type 4.
f. Mounting Bracket: Appropriate for installation.

C. Pressure Differential Indicating Transmitter, Switch, and Controller for Airflow Measurement:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Dwyer Instruments, Inc or approved equal.

2. Description:

a. Three-in-one instrument, including digital display, control relay switches, and a transmitter with a current output.
b. Field configurable for pressure, velocity, and volumetric flow applications through user interface.
c. Select instrument range based on application.

3. Performance:

a. Accuracy including hysteresis and repeatability:

1) Ranges Less than 5-Inch wg: Within 1 percent.
2) Other Ranges: Within 0.5 percent at 77 deg F.

b. Stability: Within 1 percent per year.

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c. Response Time: 250 ms.
d. Overpressure:

1) Ranges Less than 50-Inch wg: 5 psi
2) Range of 100-Inch wg: 9 psi.

e. Temperature Limits: 32 to 140 deg F.
f. Thermal Effects: 0.020 percent per deg F.
g. Warm-up Period: One hour.

4. Controller: Programming through menu keys to access five menus.

a. Security level.
b. Pressure, velocity, or flow application.
c. Engineering units.
d. K-factor for use with flow application.
e. Set-point control only; set-point and alarm operation; alarm operation as high, low, or high/low with manual; or automatic reset and delay.
f. View high and low readings.
g. Digital dampening for smoothing erratic applications.
h. Scaling of analog output to fit range and field calibration.

5. Display:

a. Four-digit digital, with minimum 0.4-inch-high alphanumeric characters.
b. Four LED indicators; two LEDs for set point and two LEDs for alarm status.

6. Operator Interface:

a. Set-point adjustment through keypad on face of instrument.
b. Zero and span adjustments accessible through menu.
c. Programming through keypad.

7. Output Analog Signal: Two-wire, 4- to 20-mA dc current source; capable of operating into a 900-ohm load.
8. Output Digital Signal: Two, SPDT relays; each rated for 1 A at 30-V ac or 30-V dc.
9. Construction:

a. Die-cast aluminum casing and bezel.
b. Connections on side and back.
c. Vertical plane mounting.
d. NEMA 250, Type 1 rating.
e. Nominal 4-inch-diameter face.
f. Mounting Bracket: Appropriate for installation.

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PART 3 - EXECUTION

3.1 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments in steam, liquid, and liquid-sealed-piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
7. Install instruments in dry gas and non-condensable-vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches) above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches.

3.2 FLOW INSTRUMENTS INSTALLATION

A. Airflow Sensors:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Transmitters:

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1. Install airflow transmitters serving an air system in a single location adjacent to or within system control panel.
2. Install liquid flow transmitters, not integral to sensors, in vicinity of sensor. Where multiple flow transmitters serving same system are located in same room, co-locate transmitters by system to provide service personnel a single and convenient location for inspection and service.

3.3 INSTRUMENT APPLICATIONS

A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

B. Duct-Mounted Airflow Sensors:

1. Measured Velocities 500 fpm and Less: Thermal airflow station.
2. Measured Velocities Greater than 500 fpm: Thermal airflow station.

C. Damper-Mounted Airflow Sensors:

1. Measured Velocities 500 fpm and Less: Thermal airflow station.
2. Measured Velocities Greater than 500 fpm: Thermal airflow station.

D. Fan-Mounted Airflow Sensors:

1. Piezometer ring fan inlet airflow sensor.

E. Airflow Switches:

1. Measured Velocities 400 fpm and Less: Polymer film sail switch.
2. Measured Velocities Greater than 400 fpm: Stainless-steel single-vane switch.

END OF SECTION 23 09 10.14

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SECTION 23 09 23

DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 – GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. DDC system for monitoring and controlling of HVAC systems.
2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

B. Related Requirements:

1. Section 230993 "Sequence of Operations for HVAC DDC" for control sequences.

1.4 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.

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4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. BAS: Building Automation System.

E. BMS: Building Management System.

F. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

G. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

H. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing of enterprise system.

I. COV: Changes of value.

J. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

K. Distributed Control: Processing of system data is de-centralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

L. DOCSIS: Data-Over Cable Service Interface Specifications.

M. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

N. HLC: Heavy load conditions.

O. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

P. LAN: Local area network.

Q. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

R. Modbus TCP/IP: An open protocol for exchange of process data.

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S. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

T. MTBF: Mean time between failures.

U. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers that communicates on peer-to-peer network for transmission of global data.

V. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

W. PDA: Personal digital assistant.

X. Peer to Peer: Networking architecture that treats all network stations as equal partners.

Y. POT: Portable operator's terminal.

Z. RAM: Random access memory.

AA. RF: Radio frequency.

BB. Router: Device connecting two or more networks at network layer.

CC. Server: Computer used to maintain system configuration, historical and programming database.

DD. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

EE. UPS: Uninterruptible power supply.

FF. USB: Universal Serial Bus.

GG. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

HH. WLED: White light emitting diode.

1.5 ACTION SUBMITTALS

A. Multiple Submissions:

1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data: For each type of product include the following:

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1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product. Including but not limited to:

    a. Operator workstation.
    b. Gateways.
    c. DDC controllers.
    d. Enclosures.
    e. Electrical power devices.
    f. Accessories.
    g. Instruments.
    h. Control dampers and actuators.
    i. Temperature sensors and T-Stats.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.
8. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
9. Schedule and design calculations for control dampers and actuators.

    a. Flow at Project design and minimum flow conditions.
    b. Face velocity at Project design and minimum airflow conditions.
    c. Pressure drop across damper at Project design and minimum airflow conditions.
    d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
    e. Maximum close-off pressure.
    f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
    g. Torque required at worst case condition for sizing actuator.
    h. Actuator selection indicating torque provided.
    i. Actuator signal to control damper (on, close or modulate).
    j. Actuator position on loss of power.
    k. Actuator position on loss of control signal.

10. Schedule and design calculations for selecting flow instruments.

    a. Instrument flow range.
    b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter and output signal for remote control.

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c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter and output signal for remote control.
d. Pressure-differential loss across instrument at Project design flow conditions.
e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

C. Software Submittal:

1. Cross-referenced listing of software to be loaded on operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Description of system database, including all data included in database, database capacity and limitations to expand database.
6. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

D. Shop Drawings:

1. General Requirements:

a. Include cover drawing with Project name, location, Owner, Engineer, Contractor, and issue date with each Shop Drawings submission.
b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
c. Prepare Drawings using CAD.

2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Plan Drawings indicating the following:

a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork, and piping.
b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
c. Operator workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller and damper connecting to DDC controller.
d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
e. Network communication cable and raceway routing.
f. Proposed routing of wiring, cabling, and conduit, coordinated with building services for review before installation.

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4. Schematic drawings for each controlled HVAC system indicating the following:

    a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper, if included in Project.
    b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
    c. A graphic showing location of control I/O in proper relationship to HVAC system.
    d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
    e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
    f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
    g. Narrative sequence of operation.
    h. Graphic sequence of operation, showing all inputs and output logical blocks.

5. Control panel drawings indicating the following:

    a. Panel dimensions, materials, size, and location of field cable and raceways connections.
    b. Interior subpanel layout, drawn to scale and showing all internal components, cabling, and wiring raceways, nameplates and allocated spare space.
    c. Front, rear, and side elevations and nameplate legend.
    d. Unique drawing for each panel.

6. DDC system network riser diagram indicating the following:

    a. Connections points into the DDC System.
    b. Each device connected to network with unique identification for each.
    c. Interconnection of each different network in DDC system.
    d. For each network, indicate communication protocol, speed, and physical means of interconnecting network devices, such as copper cable type, or fiber-optic cable type. Indicate raceway type and size for each.
    e. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

7. DDC system electrical power riser diagram indicating the following:

    a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
    b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
    c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
    d. Power wiring type and size, race type, and size for each.

8. Color graphics indicating the following:

    a. Itemized list of color graphic displays to be provided.

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b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
c. Intended operator access between related hierarchical display screens.

E. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:

a. Loss of power.
b. Loss of network communication signal.
c. Loss of controller signals to inputs and outpoints.
d. Operator workstation failure.
e. Server failure.
f. Gateway failure.
g. Network failure
h. Controller failure.
i. Instrument failure.
j. Control damper actuator failure.
k. Temperature sensor failure.

4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. Manufacturer's qualification data.
2. Testing agency's qualifications data.

B. Product Test Reports: For each product that requires testing to be performed by a qualified testing agency.

C. Preconstruction Test Reports: For each separate test performed.

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

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1. In addition to items specified in Division 1 "Operation and Maintenance Data," include the following:

    a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
    b. Testing reports and checklists of completed final versions of reports, checklists, and trend logs.
    c. As-built versions of submittal Product Data.
    d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
    e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
    f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
    g. Engineering, installation, and maintenance manuals that explain how to:

        1) Design and install new points, panels, and other hardware.
        2) Perform preventive maintenance and calibration.
        3) Debug hardware problems.
        4) Repair or replace hardware.

    h. Backup copy of graphic files, programs, and database on electronic media such as flash drives.
    i. List of recommended spare parts with part numbers and suppliers.
    j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
    k. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
    l. Licenses, guarantees, and warranty documents.
    m. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
    n. Owner training materials.

1.7 QUALITY ASSURANCE

A. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. Demonstrated past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
3. Each person assigned to Project shall have demonstrated past experience.
4. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
5. Service and maintenance staff assigned to support Project during warranty period.
6. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion

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1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.

a. Install updates only after receiving Owner's written authorization.

3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: Two years from date of Substantial Completion.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. State pre-approved manufacturers/systems shall be one of the following:

B. Automated Logic by Radius Systems

C. Building Logix / Lynxspring / KMC Controls by Seiberlich Trane

D. Johnson Controls by Modern Controls

E. Approved Equal by the State

2.2 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 WEB ACCESS

A. DDC system shall be Web compatible.

1. Web-Compatible Access to DDC System:

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a. Operator workstation and server shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
b. DDC system shall support Web browser access to building data. Operator using a standard Web browser shall be able to access control graphics and change adjustable set points.
c. Web access shall be password protected.

2.4 PERFORMANCE REQUIREMENTS

A. System Performance Objectives:

1. DDC system shall manage HVAC systems.
2. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
3. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
4. DDC system shall operate while unattended by an operator and through operator interaction.
5. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

C. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

D. DDC System Data Storage:

1. Include server(s) with disk drive data storage to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
2. When logged onto a server, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
3. Server(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.
4. Server(s) shall use IT industry-standard database platforms such as Microsoft SQL Server and Microsoft Data Engine (MSDE).

E. Future Expandability:

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1. DDC system size shall be expandable to an ultimate capacity of at least 25% of total I/O points indicated.
2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.

F. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

1. Energy:

   a. Thermal: Within 3 percent of reading.
   b. Electric Power: Within 1 percent of reading.
   c. Requirements indicated on Drawings for meters not supplied by utility.

2. Flow:

   a. Air: Within 2 percent of design flow rate.

3. Moisture (Relative Humidity):

   a. Air: Within 5 percent RH.
   b. Space: Within 5 percent RH.
   c. Outdoor: Within 5 percent RH.

4. Pressure:

   a. Air, Ducts and Equipment: 1 percent of instrument span.

5. Speed: Within 5 percent of reading.
6. Temperature (Dry Bulb, Wet Bulb and Dew Point):

   a. Air: Within 1 deg F.
   b. Space: Within 1 deg F.
   c. Outdoor: Within 2 deg F.

G. Performance Standards: System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Graphic Display: A graphic with 20 dynamic points shall display with current data within 10 sec.
2. Graphic Refresh: A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
3. Configuration and Tuning Screens: Screens used for configuring, calibrating, or tuning points, control loops, and similar control logic shall automatically refresh with 6 sec.
4. Alarm Response Time: An object that goes into alarm shall be annunciated at the workstation within 15 sec.

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5. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
6. Performance: Programmable controllers shall be able to completely execute DDC SYSTEM control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
7. Multiple Alarm Annunciations: Each workstation on the network shall receive alarms within 5 sec. of other workstations.

H. Data Base Update: Under normal system operation, the Workstation Equipment point data base shall be updated so that any change in analog value or digital status is no older than ten (10) seconds.

I. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.

    a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

    a. Outdoors, Protected: Type 3.
    b. Outdoors, Unprotected: Type 4.
    c. Indoors, Heated with Ventilation: Type 2.
    d. Indoors, Heated and Air Conditioned: Type 1.
    e. Mechanical Equipment Rooms: Type 4
    f. Within Duct Systems and Air-Moving Equipment: Type 4.

J. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

K. UPS:

1. Power the following DDC system products by UPS units:

    a. Operator workstation.
    b. Printer.
    c. Server.
    d. Gateways.
    e. DDC controllers.

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L. Continuity of Operation after Electric Power Interruption:

1. Automatic Restart: Entire DDC System shall have automatic restart software that causes system to actuate automatic restart without human intervention after an electrical power outage and UPS battery drain and subsequent restart.

a. Workstation Equipment Power Failure: During normal operation, each workstation shall continuously update all system information on its own hard drive. Provide safeguard procedures to assure that any interruptions of power during the updating procedure will not destroy memory record of any data file already on the drive. During each update procedure, a time tag shall be stored in a file with current month, day, hour, and minute. At time of power failure at workstation equipment, all workstation equipment shall go through an orderly shutdown such that no system information and/or programming information is destroyed or lost. Upon power restoration after a power failure, each workstation shall restart. Power failure at workstation equipment shall not affect control functions of BCU(s).

b. DDC System Power Failure: Provide safeguard procedures to assure that any interruptions of power during operation of DDC System will not cause a loss of any programming information and/or stored database information from input devices. At the time of power failure at DDC System all functions of DDC System shall shutdown orderly (and without damaging any connected equipment) such that all connected equipment shall either be positioned to "Fail Safe" mode or be de-energized and cease to operate. Upon power restoration and after a power failure, DDC System shall generate an automatic restart command which shall cause DDC System to restart, and DDC System shall automatically restart and DDC System shall automatically restart corresponding software, including adjustment of all optimum start-stop and schedule start-stop programs. DDC System shall review all programs that should have been executed during power failure and shall energize appropriate equipment sequentially. DDC System shall resort each point to proper state as if power failure has not occurred (except for update of current time and date). All major electrical loads shall be sequentially restarted with adjustable time delays.

M. Power Line Surge Protection: Protect equipment power supplies from power line surges to 1000 V ac rms. Provide protection of equipment at ground potential to ensure protection against surges. Transient surge protection shall be incorporated into design/manufacture of each RCP/ASC/TCU and operator's workstation to protect electrical components. Do not use fuses for surge protection.

N. Communication Links Surge Protection: Protect communications equipment against surges induced on any communications link to 1000 V ac rms. Cables and conductors which serve as communications links between BAS OWS, Servers, Network Controllers and Remote-Control Panels shall have surge protection circuits installed at each end. Do not use fuses for surge protection.

2.5 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop and portable operator workstation with hardwired connection through LAN port.

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2. Remote connection using outside of system personal computer or PDA through Web access.
3. Remote connection using portable operator workstation and modem.

B. Access to the system, regardless of operator means used, shall be transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable operator workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. MDF Room.

D. Desktop Workstation:

1. Connect to DDC system LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.
3. Able to communicate, with modems, remotely with any device connected to any DDC system LAN.
4. Communication via a modem shall not interfere with LAN activity and LAN activity shall not prevent workstation from handling incoming calls.

E. Portable Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.
3. Connect to DDC system LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
4. Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
5. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
6. Have dynamic graphic displays that are identical to desktop workstations.

F. POT:

1. Connect DDC controller through a communications port local to controller.
2. Able to communicate with any DDC system controller that is directly connected to DDC system.

G. Telephone Communications:

1. Through use of a standard modem, operator shall be able to communicate with any device connected to any system LAN.
2. Have auto-dial and auto-answer communications to allow desktop and portable workstations and DDC controllers to communicate with remote workstations and remote DDC controllers via telephone lines.

a. Desktop and Portable Operator Workstation Computers with Modems:

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1) Operators shall be able to perform all control functions, report functions, and database generation and modification functions as if directly connected to system LAN.
2) Have routines to automatically answer calls, and either file or display information sent remotely.
3) Communications taking place over telephone lines shall be completely transparent to operator.
4) Dial-up program shall maintain a user-definable cross-reference and associated telephone numbers, so it is not required to remember or manually dial telephone numbers.

b. DDC Controllers:

1) Not have modems unless specifically indicated for a unique controller.
2) Analyze and prioritize alarms to minimize initiation of calls.
3) Buffer noncritical alarms in memory and report them as a group of alarms, or until an operator manually requests an upload.
4) Make provisions for handling busy signals, no-answers, and incomplete data transfers.
5) Call default devices when communications cannot be established with primary devices.

H. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.

I. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.6 NETWORKS

A. Acceptable networks for connecting operator workstations and network controllers include the following:

1. IP.
2. IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:

1. IP.
2. IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:

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1. IP.
2. IEEE 8802-3, Ethernet.

2.7 NETWORK COMMUNICATION PROTCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to public and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

C. Industry Standard Protocols:

1. DDC system shall use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:

    a. ASHRAE 135.

2. Operator workstations and network controllers shall communicate through ASHRAE 135 protocol.
3. Portions of DDC system networks using ASHRAE 135 communication protocol shall be an open implementation of network devices complying with ASHRAE 135. Network devices shall be tested and listed by BACnet Testing Laboratories.
4. Portions of DDC system networks using Modbus Application Protocol Specification V1.1b communication protocol shall be an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b.
5. Gateways shall be used to connect networks and network devices using different protocols.

2.8 DESKTOP OPERATOR WORKSTATIONS

A. Performance Requirements:

1. Performance requirements may dictate equipment exceeding the minimum requirements indicated.
2. Energy Star complaint.

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B. Personal Computer:

1. Minimum Processor Speed: 3.3 gigahertz.
2. RAM:

   a. Capacity: 24 GB.
   b. Expandable Capacity: 24 GB.

3. Hard Drive:

   a. Number of Hard Drives: Two.
   b. Capacity: 1 TB each.

4. Optical Read and Write Drive:

   a. Include with at least 2 MB of data buffer.
   b. Type: HD.
   c. Average access time of 150 ms or less.
   d. MTBF of at least 100,000 power-on hours.

5. At least four expansion slots of 64 bit.
6. Video Card:

   a. Resolution: 1920 by 1200 pixels.
   b. RAM: 8 GB.

7. Sound Card:

   a. At least 128 voice wavetable synthesis.
   b. Capable of delivering three-dimensional sound effects.
   c. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.

8. Network Interface Card: Include card with connection, as applicable.

   a. 10-100-1000 base TX Ethernet with RJ45 connector port.
   b. 100 base FX Ethernet with SC or ST port.

9. Modem:

   a. Ethernet connectivity.

10. I/O Ports:

    a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
    b. One serial port.
    c. One parallel port.
    d. Two PS/2 ports.
    e. One RJ-45.
    f. One stereo line-in and headphone line-out on back panel.

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g. One microphone and headphone connector on front panel.
h. One IEEE 1394 on front and back panel with PCI-e card.
i. One ESATA port on back panel.

11. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

C. Keyboard:

1. 101 enhanced keyboard.
2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
3. Wireless operation within up to 72 inches in front of workstation.

D. Pointing Device:

1. Either a two- or three-button mouse.
2. Wireless operation within up to 72 inches in front of workstation.

E. Flat Panel Display Monitor:

1. Display:

a. Color display with 21 inches diagonal viewable area.
b. Digital or analog input signal.
c. Aspect Ratio: 16 to 9.
d. Antiglare display.
e. Dynamic Contrast Ratio: 50000 to 1.
f. Tilt adjustable base.
g. Energy Star compliant.
h. Resolution: 1920 by 1080 pixels at 60 Hz with pixel size of 0.277 mm or smaller.
i. Number of Displays: One.

F. Speakers:

1. Two, with individual controls for volume, bass, and treble.
2. Signal to Noise Ratio: At least 65 dB.
3. Power: At least 4 W per speaker/channel.
4. Magnetic shielding to prevent distortion on the video monitor.

G. I/O Cabling: Include applicable cabling to connect I/O devices.

2.9 SERVERS

A. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. Energy Star compliant.
3. Minimum Processor Speed: 3.3 gigahertz.

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4. RAM:

   a. Capacity: 24GB.
   b. Expandable Capacity: 24 GB.

5. Redundant Array of Independent Disks: Two configuration.
6. Drive Bays: Eight at 2.5 inches or eight at 3.5 inches.
7. Hard-Drive Storage: Three drives each with 2 TB storage and nominal rotational speed of 7200 rpm.
8. Network Interface: Dual port Ethernet.
9. DVD +RW Drive.
10. Keyboard and mouse.
11. Next-day on-site warranty for two-year period following Substantial Completion.

B. Servers shall include the following:

1. Full-feature backup server (server and backup minimum requirement).
2. Software licenses.
3. CAT-6 cable installation between server(s) and network.

C. Web Server:

1. If required to be separate, include Web server hardware and software to match, except backup server is not required.
2. Firewalls between server Web and networks.
3. Password protection for access to server from Web server.
4. CAT 6 cable installation between the server(s) and building Ethernet network.

D. Power each server through a 3,000 VA UPS unit.

2.10 PRINTER

A. Color Laser Printer:

1. 1200 by 1200 dots per inch resolution black and white, 1200 by 1200 dots per inch resolution black and white and color.
2. First sheet printed within 10 seconds.
3. Print buffer with at least 512 MB of RAM, expandable to at least one GB.
4. Complies with Energy Star requirements.
5. Capable of handling letter, legal, and tabloid (11x17) size paper.
6. Two paper trays.

2.11 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 64-bit operating system that allows concurrent execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating Microsoft Windows applications.

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3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software shall manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:

    a. Operator access to DDC system shall be under password control.
    b. An alphanumeric password shall be field assignable to each operator.
    c. Operators shall be able to access DDC system by entry of proper password.
    d. Operator password shall be same regardless of which computer or other interface means is used.
    e. Additions or changes made to passwords shall be updated automatically.
    f. Each operator shall be assigned an access level to restrict access to data and functions the operator is cable of performing.
    g. Software shall have at least five access levels.
    h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
    i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.

7. Operators shall be able to perform commands including, but not limited to, the following:

    a. Start or stop selected equipment.
    b. Adjust set points.
    c. Add, modify, and delete time programming.
    d. Enable and disable process execution.
    e. Lock and unlock alarm reporting for each point.
    f. Enable and disable totalization for each point.
    g. Enable and disable trending for each point.

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h. Override control loop set points.
i. Enter temporary override schedules.
j. Define holiday schedules.
k. Change time and date.
l. Enter and modify analog alarm limits.
m. Enter and modify analog warning limits.
n. View limits.
o. Enable and disable demand limiting.
p. Enable and disable duty cycle.
q. Display logic programming for each control sequence.

8. Reporting:

a. Generated automatically and manually.
b. Sent to displays, printers, and disk files.
c. Types of Reporting:

1) General listing of points.
2) List points currently in alarm.
3) List of off-line points.
4) List points currently in override status.
5) List of disabled points.
6) List points currently locked out.
7) List of items defined in a "Follow-Up" file.
8) List weekly schedules.
9) List holiday programming.
10) List of limits and deadbands.

9. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
4. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.
5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
7. Graphics are to be online programmable and under password control.

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8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics shall also contain software points.
10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
11. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
14. Include operator with means to directly access graphics without going through penetration path.
15. Dynamic data shall be assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
18. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.

    a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
    b. Keyboard equivalent shall be available for those operators with that preference.

19. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
20. Help Features:

    a. On-line context-sensitive help utility to facilitate operator training and understanding.
    b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.

        1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.

    c. Available for Every Menu Item:

        1) Index items for each system menu item.

21. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.

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a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers and electrical symbols.
b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:

1) Define background screens.
2) Define connecting lines and curves.
3) Locate, orient and size descriptive text.
4) Define and display colors for all elements.
5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

a. Room layouts with room identification and name.
b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
c. Location and identification of each hardware point being controlled or monitored by DDC system.

3. Control schematic for each of following, including a graphic system schematic representation with point identification, set point and dynamic value indication and control logic diagram.
4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways, and operator workstation.

E. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
3. As a minimum, include the following modification capability:

a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
b. Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.
c. System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC

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controller enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.

d. System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.

e. Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.

f. Point related change capability shall include the following:

1) System and point enable and disable.
2) Run-time enable and disable.
3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
4) Assignment of alarm and warning limits.

g. Application program change capability shall include the following:

1) Enable and disable of software programs.
2) Programming changes.
3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices, and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.

4. Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.

5. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:

a. Proportional control (P).
b. Proportional plus integral (PI).
c. Proportional plus integral plus derivative (PID).
d. Adaptive and intelligent self-learning control.

1) Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.
2) Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

6. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.

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7. Logic operators such as "And" "Or" "Not," and others that are part of a standard set available with a high-level language.
8. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.
9. Relational operators such as "Equal To," "Not Equal To," "Less Than" "Greater Than" and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways, and other network devices.
2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display shall include the following:

    a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
    b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, building 110, 2nd Floor, Room 212."
    c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
    d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.

5. Alarms shall be directed to appropriate operator workstation, printer, and individual operators by privilege level and segregation assignments.
6. Send e-mail alarm messages to designated operators.
7. Send e-mail, page, text and voice messages to designated operators for critical alarms.
8. Alarms shall be categorized and processed by class.

    a. Class 1:

        1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
        2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
        3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.

    b. Class 2:

        1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
        2) Acknowledgement may be through a multiple alarm acknowledgment.

    c. Class 3:

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1) General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.
2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.
4) Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.

d. Class 4:

1) Routine maintenance or other types of warning alarms.
2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Each report shall be definable as to data content, format, interval and date.
3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation for historical reporting.
4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Reports and logs shall be stored on workstation hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.

H. Standard Reports: Standard DDC system reports shall be provided, and operator shall be able to customize reports later.

1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:

a. Alarm history.
b. System messages.
c. System events.
d. Trends.

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I. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

J. Tenant Override Reports: Prepare Project-specific reports.

1. Weekly report showing daily total time in hours that each tenant has requested after-hours HVAC.
2. Monthly report showing daily total time in hours that each tenant has requested after-hours HVAC.
3. Annual summary report that shows after-hours HVAC usage on a monthly basis.

K. HVAC Equipment Reports: Prepare Project-specific reports.

L. Energy Reports: Prepare Project-specific daily, weekly, monthly, and annual energy reports.

1. Prepare report for each energy utility, indicating the following:

a. Time period being reported with beginning and end date, and time indicated.
b. Consumption in units of measure commonly used to report specific utility consumption over time.
c. Cost per utility unit.
d. Utility cost per unit area.
e. Convert all utilities to a common energy consumption unit of measure and report for each utility.
f. Consumption per unit area using common unit of measure.

M. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending. The systems controlled and/or monitored shall include, but are not limited to the following:

a. Heating and Cooling Systems
b. Domestic Hot Water
c. Stairwell and Elevator Shaft Pressurization Systems

2. Trends shall be associated into groups, and a trend report shall be set up for each group.
3. Trends shall be stored within DDC controller and uploaded to hard drives automatically.
4. Preset trend intervals for each I/O point after review with Owner.
5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
6. When drive storage memory is full, most recent data shall overwrite oldest data.
7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

N. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.

1. Each trend shall include interval, start time, and stop time.

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2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation hard drives.
3. Data shall be retrievable for use in spreadsheets and standard database programs.

O. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programing software shall be as follows:

    a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.

        1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
        2) Programming tools shall be viewable in real time to show present values and logical results of each function block.

    b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements, and constraints.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

P. Database Management Software:

1. Where a separate SQL database is used for information storage, DDC system shall include database management software that separates database monitoring and managing functions by supporting multiple separate windows.
2. Database secure access shall be accomplished using standard SQL authentication including ability to access data for use outside of DDC system applications.
3. Database management function shall include summarized information on trend, alarm, event, and audit for the following database management actions:

    a. Backup.
    b. Purge.
    c. Restore.

4. Database management software shall support the following:

    a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
    b. Maintenance: Include method of purging records from trend, alarm, event and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
    c. Backup: Include means to create a database backup file and select a storage location.

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d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.

5. Database management software shall include information of current database activity, including the following:

a. Ready.
b. Purging record from a database.
c. Action failed.
d. Refreshing statistics.
e. Restoring database.
f. Shrinking a database.
g. Backing up a database.
h. Resetting Internet information services.
i. Starting network device manager.
j. Shutting down the network device manager.
k. Action successful.

6. Database management software monitoring functions shall continuously read database information once operator has logged on.
7. Include operator notification through on-screen pop-up display and e-mail message when database value has exceeded a warning or alarm limit.
8. Monitoring settings window shall have the following sections:

a. Allow operator to set and review scan intervals and start times.
b. E-mail: Allow operator to create and review e-mail and phone text messages to be delivered when a warning or an alarm is generated.
c. Warning: Allow operator to define warning limit parameters, set reminder frequency and link e-mail message.
d. Alarm: Allow operator to define alarm limit parameters, set reminder frequency and link e-mail message.
e. Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event, and audit databases as well as operator proper security access to restore a database.

9. Monitoring settings taskbar shall include the following informational icons:

a. Normal: Indicates by color and size, or other easily identifiable means that all databases are within their limits.
b. Warning: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their warning limit.
c. Alarm: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their alarm limit.

Q. Real-Time Control Dashboard:

1. Provide in chart form a display indicating all mechanical system equipment and components.
2. The data listed for each system component should include that which is listed under "display and trending" in the "Sequence of Operations for HVAC Controls and Building Interface" section.

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3. This display shall be in Real-Time and indicate all systems components simultaneously.
4. Separate page of all abbreviations used on the dashboard screens shall be created and available for review.
5. The points available in the charts of the dashboard shall correspond with the points displayed on the graphic screens. The same abbreviation and/or symbol shall be used for the same variable on the dashboard and on the graphic screens.
6. All data displayed on the dashboard shall be able to be saved and printed in the Excel spreadsheet format.
7. The sample of a dashboard is included below. The exact format and content of the dashboard shall be coordinated with the Client/User.
8. Provide current weather data and system optimization and anticipation based on historical weather data.

2.12 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, air handling units and variable-speed drives.

B. Include gateways to connect BACnet to non-BACnet devices only when specifically requested and approved by Owner.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:

1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.13 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

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C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware shall be suitable for the anticipated ambient conditions.

F. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

G. Input and Output Point Interface:

1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.

2.14 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers that perform scheduling shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.

B. Communication:

1. Network controllers shall communicate with other devices on DDC system network.

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2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.15 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers that perform scheduling shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

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3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.15 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.
2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.16 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
2. Control functions shall be executed within controllers using DDC algorithms.
3. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Operator access shall be secured using individual security passwords and user names.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

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C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

a. Include separate schedules for each day of week.
b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
c. Each schedule may consist of up to 10 events.
d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

a. Include ability for operator to designate any day of the year as an exception schedule.
b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

a. Include capability for operator to define up to 99 special or holiday schedules.
b. Schedules may be placed on scheduling calendar and will be repeated each year.
c. Operator shall be able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Application shall include operator with a method of grouping together equipment based on function and location.
3. Group may then be used for scheduling and other applications.

E. Alarm Reporting:

1. Operator shall be able to determine action to be taken in event of an alarm.
2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

F. Remote Communication:

1. System shall have ability to dial out in the event of an alarm.

G. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

H. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

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I. Control Loops:

1. Support any of the following control loops, as applicable to control required:

a. Two-position (on/off, open/close, slow/fast) control.
b. Proportional control.
c. Proportional plus integral (PI) control.
d. Proportional plus integral plus derivative (PID) control.

1) Include PID algorithms with direct or reverse action and anti-windup.
2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
3) Controlled variable, set point, and PID gains shall be operator-selectable.

e. Adaptive (automatic tuning).

J. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.

K. Energy Calculations:

1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
3. Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

L. Run-Time Totalization:

1. Include software to totalize run-times for applicable points.
2. A high run-time alarm shall be assigned, if required, by operator.

2.17 ELECTRICAL POWER DEVICES

A. DC Power Supply:

1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
2. Enclose circuitry in a housing.
3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
4. Performance:

a. Output voltage nominally 25-V dc within 5 percent.
b. Output current up to 100 mA.
c. Input voltage nominally 120-V ac, 60 Hz.

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d. Load regulation within 0.5 percent from zero- to 100-mA load.
e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.18 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS

A. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.

B. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.

1. Larger-capacity units shall be provided for systems with larger connected loads.
2. UPS shall provide 15 minutes of battery power.

C. Performance:

1. Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.
2. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
3. Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.
4. On Battery Output Voltage: Sine wave.
5. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
6. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.
7. Transfer Time: 6 ms.
8. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.

D. UPS shall be automatic during fault or overload conditions.

E. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.

F. Include front panel with power switch and visual indication of power, battery, fault and temperature.

G. Unit shall include an audible alarm of faults and front panel silence feature.

H. Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.

I. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure).

J. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.

K. Include tower models installed in ventilated cabinets to the particular installation location.

2.19 ACCESSORIES

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A. Pressure Electric Switches:

1. Diaphragm-operated snap acting switch.
2. Set point adjustable from 3 to 20 psig.
3. Differential adjustable from 2 to 6 psig.
4. Rated for resistance loads at 120-V ac.
5. Body and switch housing shall be metal.

B. Damper Blade Limit Switches:

1. Sense positive open and/or closed position of the damper blades.
2. NEMA 250, Type 13, oil-tight construction.
3. Arrange for the mounting application.
4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

C. Instrument Enclosures:

1. Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
2. NRTL listed and labeled to UL 50.
3. Sized to include at least 25 percent spare area on subpanel.
4. Instrument(s) mounted within enclosure on internal subpanel(s).
5. Enclosure face with engraved, laminated phenolic nameplate for each instrument within enclosure.
6. Enclosures housing multiple instruments shall route wiring within enclosure in a raceway having a continuous removable cover.
7. Enclosures larger than 12 inches shall have a hinged full-size face cover.
8. Equip enclosure with lock and common key.

2.20 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Engraved tag bearing unique identification.

   a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Tag shall consist of white lettering on black background.
3. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer.
4. Tag shall be fastened with drive pins.
5. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

B. Raceway and Boxes:

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1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.

C. Equipment Warning Labels:

1. Acrylic label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inch beyond white border.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.

1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
2. Equipment to Be Connected:

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a. Air handling units with packaged controls.
b. VRF systems with packaged controls.
c. VAV and fan powered boxes.
d. Unit heaters, cabinet unit heaters and wall heaters.
e. Stairwell and elevator shaft pressurization systems.
f. Ventilation fans and exhaust air fans.
g. Domestic water booster pumps.

B. Communication Interface to Other Building Systems:

1. DDC system shall have a communication interface with systems having a communication interface.
2. Systems to Be Connected:

a. Fire-alarm system specified in Section 284611.11 " Addressable Fire Alarm System."
b. Domestic water and gas sub meters.

3.3 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

B. Deliver all duct mounted devices to the duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

C. Deliver all pipe mounted devices to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.

3.4 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated, including manufacturer’s recommendations.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, conduit, wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

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F. Firestop penetrations made in fire-rated assemblies.

G. Seal penetrations made in acoustically rated assemblies.

H. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

I. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

J. If a field-mounted device or piece of equipment requires 120 V ac service and is mounted at a different location from 120 V ac power source provided under Electrical: Division 26, provide extensions to power wiring, including conduit, junction boxes, and other hardware, in accordance with Electrical: Division 26. This requirement shall also apply to devices powered by 24 V ac.

K. Damper actuators that are placed in plenums shall be mounted on damper frames. Damper actuators shall not be installed in ducts or fresh-air intakes.

L. Thermostats, temperature sensors, humidistats and humidity sensors located on exterior walls shall be mounted on back-insulated blocks.

M. Provide labor for coordination and preparation during third party commissioning and testing/ balancing of systems as performed under Testing and Balancing of Mechanical Systems: Division 1 and Preparation for Testing and Balancing of Mechanical Systems: Division 23.

N. Provide required cooperation and coordination with Electrical: Division 26 such that all power and ground wiring is provided in accordance with DDC system equipment manufacturer's written recommendations. DDC system supplier/installer shall make final electrical connections to DDC system equipment.

J. Keep cable runs as short as possible, allowing extra length for connecting to terminal boards. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners or through penetrations. Provide strain relief loops in wiring harness between sub-panel terminal points and panel-mounted components.

K. Temperature:

1. RTDs: RTDs may be used in ducts, piping or spaces. When RTD is installed in pipes, it shall be installed in a thermowell. Coordinate thermowell locations with Mechanical Installer. When installed in airstreams or spaces, RTDs shall be rigidly supported. RTDs used for space-temperature sensing shall include a housing suitable for wall mounting. RTDs used for outside-air sensing shall have an instrument shelter to minimize solar effects, and shall be mounted to isolate building thermal effects. All RTD assemblies shall be readily accessible and installed in such a manner as to allow for easy replacement. Sensors located outdoors shall be NEMA 4 rated.
2. Temperature Switches: Install temperature switches as specified for RTDs. Temperature switches shall be verified by calibration. Switch contact ratings shall be selected so as to meet expected load.

L. Pressure:

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1. Pressure Switches: Pressure switches shall be adjusted to proper setpoint, and shall be verified by calibration. Pressure switches shall be mounted higher than process connection.
2. Size (for specific range) and adjust each differential-pressure switch used for fan status to ensure reliable monitoring and eliminate false status feedback.

M. Provide weathershield/enclosure to protect actuators and linkages from outside conditions of snow and ice build-up.

N. Provide NEMA 4 enclosures for electric or electronic devices mounted in outdoor locations.

O. Keep cable runs as short as possible, allowing extra length for connecting to terminal boards. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners or through penetrations. Provide strain relief loops in wiring harness between sub-panel terminal points and panel-mounted components.

3.5 OPERATOR WORKSTATION INSTALLATION

A. Desktop Operator Workstations Installation:

1. Install software on workstation and verify software functions properly.
2. Develop Project-specific graphics, trends, reports, logs and historical database.
3. Power workstation through a dedicated UPS unit. Locate UPS adjacent to workstation.

B. Color Graphics Application:

1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Engineer's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's and Engineer's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.6 GATEWAY INSTALLATION

A. Install gateways if required for DDC system communication interface requirements indicated.

B. Test gateways to verify that communication interfaces function properly.

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3.7 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.

F. Installation of Programmable Application Controllers:

1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.

G. Application-Specific Controllers:

1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.8 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Division 26 for electrical power circuit breakers.

D. Comply with requirements in Division 26 for electrical power conductors and cables.

E. Comply with requirements in Division 26 for electrical power raceways and boxes.

3.9 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Division 26 for identification products and installation.

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B. Install engraved phenolic nameplate with unique identification on face for each of the following:

1. Gateway.
2. DDC controller.
3. Enclosure.
4. Electrical power device.
5. UPS unit.

C. Install engraved phenolic nameplate with unique instrument identification on face of each instrument connected to a DDC controller.

D. Where product is installed above accessible tile ceiling, also install matching engraved phenolic nameplate with identification on face of ceiling grid located directly below.

E. Where product is installed above an inaccessible ceiling, also install engraved phenolic nameplate with identification on face of access door directly below.

F. Warning Labels:

1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
2. Shall be located in highly visible location near power service entry points.

3.10 NETWORK INSTALLATION

A. Install copper cable or fiber-optic cable when connecting between network devices.

3.11 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

3.12 CONTROL WIRE, CABLE, AND RACEWAYS INSTALLATION

A. Wiring Method:

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways, boxes, and conduits specified in Division 26.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Field Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Conduit Installation:

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1. Install conduit expansion joints where conduit runs exceed 200 feet, and conduit crosses building expansion joints.
2. Coordinate conduit routing with other trades to avoid conflicts with ducts, pipes and equipment and service clearance.
3. Maintain at least 3-inch separation where conduits run axially above or below ducts and pipes.
4. Limit above-grade conduit runs to 100 feet without pull or junction box.
5. Do not install raceways or electrical items on any "explosion-relief" walls, or rotating equipment.
6. Do not fasten conduits onto the bottom side of a metal deck roof.
7. Flexible conduit is permitted only where flexibility and vibration control is required.
8. Limit flexible conduit to 3 feet long.
9. Conduit shall be continuous from outlet to outlet, from outlet to enclosures, pull and junction boxes, and shall be secured to boxes in such manner that each system shall be electrically continuous throughout.
10. Direct bury conduits underground or install in concrete-encased duct bank where indicated.

    a. Use rigid, nonmetallic, Schedule 80 PVC.
    b. Provide a burial depth according to NFPA 70, but not less than 24 inches.

11. Secure threaded conduit entering an instrument enclosure, cabinet, box, and trough, with a locknut on outside and inside, such that conduit system is electrically continuous throughout. Provide a metal bushing on inside with insulated throats. Locknuts shall be the type designed to bite into the metal or, on inside of enclosure, shall have a grounding wedge lug under locknut.
12. Conduit box-type connectors for conduit entering enclosures shall have an insulated throat.
13. Connect conduit entering enclosures in wet locations with box-type connectors or with watertight sealing locknuts or other fittings.
14. Offset conduits where entering surface-mounted equipment.
15. Seal conduit runs used by sealing fittings to prevent the circulation of air for the following:

    a. Conduit extending from interior to exterior of building.
    b. Conduit extending into pressurized duct and equipment.
    c. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.

E. Wire and Cable Installation:

1. Cables serving a common system may be grouped in a common raceway. Install control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
2. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

    a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

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3. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
5. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.
6. Provide strain relief.
7. Terminate wiring in a junction box.

    a. Clamp cable over jacket in junction box.
    b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

8. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
9. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
10. Keep runs short. Allow extra length for connecting to terminal boards. Do not bend flexible coaxial cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
11. Ground wire shall be copper and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.
12. Wire and cable shall be continuous from terminal to terminal without splices.
13. Use insulated spade lugs for wire and cable connection to screw terminals.
14. Use shielded cable to transmitters.
15. Use shielded cable to temperature sensors.
16. Perform continuity and meager testing on wire and cable after installation.
17. Do not install bruised, kinked, scored, deformed, or abraded wire and cable. Remove and discard wire and cable if damaged during installation and replace it with new cable.
18. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
19. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
20. Protection from Electro-Magnetic Interference (EMI): Provide installation free of (EMI). As a minimum, comply with the following requirements:

    a. Comply with BICSI TDMM and TIA 569-C for separating unshielded cable from potential EMI sources, including electrical power lines and equipment.
    b. Separation between open cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

        1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
        2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
        3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

    c. Separation between cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

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1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

d. Separation between cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

e. Separation between Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.
f. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.13 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the third-party commissioning agent:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer.
5. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
6. Test Equipment: Use a fiber-optic time domain reflectometer for testing the length and optical connectivity.
7. Test Results: Record test results and submit copy of test results for Project record.

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3.14 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Control Damper Checkout:

1. Verify that control dampers are installed correctly for flow direction.
2. Verify that proper blade alignment, either parallel or opposed, has been provided.
3. Verify that damper frame attachment is properly secured and sealed.
4. Verify that damper actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that damper blade travel is unobstructed.

E. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
7. For temperature instruments:

a. Verify sensing element type and proper material.
b. Verify length and insertion.

3.15 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment for review by the third-party commissioning agent.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

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F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

K. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

N. Switches: Calibrate switches to make or break contact at set points indicated.

O. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

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3.16 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase, and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.17 DDC CONTROLLER I/O CONTOL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:

   a. Upper quarter of range.
   b. Lower quarter of range.
   c. At midpoint of range.

8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

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3.18 FINAL REVIEW

A. Submit written request to Commissioning Agent and Construction Manager when DDC system is ready for final review. Written request shall state the following:

1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Review by Commissioning Agent and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor, and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.

3.19 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

3.20 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for one year.

B. Provide ten software licenses with the system.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within one year from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

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3.21 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

1. Training shall be six, four-hour sessions, professionally video recorded.
2. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.

END OF SECTION 23 09 23

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SEQUENCE OF OPERATIONS FOR HVAC DDC

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section includes control sequences for DDC for HVAC systems, subsystems, and equipment.

B. Related Requirements:

1. Section 230923 "DDC Systems for HVAC" for control equipment.

1.4 DEFINITIONS

A. Analog Output: Proportional output signal (zero- to 10-V dc, 4 to 20 mA).

B. Binary Output: On/off output signal or contact closure.

C. DDC: Direct digital control.

D. Digital Output: Data output that must be interpreted digitally.

1.5 ACTION SUBMITTALS

A. Product Data:

1. An instrumentation list for each controlled system. Label each element of the controlled system in table format. Show, in the table element name, type of device, manufacturer, model number, and control device product data sheet number.
2. A complete description of the operation of the control system, including sequences of operation. Include and reference a schematic diagram of the controlled system.

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B. Shop Drawings:

1. Riser diagrams showing control network layout, communication protocol, and wire types.
2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.6 PACKAGED ROOFTOP UNIT CONTROL SEQUENCES

A. Time Schedule:

1. Occupied Time Schedule:

a. Input:

1) Device: DDC controller.
2) Location: Time schedule.
3) Transference: DDC controller.

b. Output:

1) Device: DDC controller.

c. Action:

1) Enable startup, initiation, and control.
2) Energize unit on occupied cycle.
3) Energize unit on day/night cycle.
4) Energize unit on duty cycle.
5) Energize return-air fans 30 seconds after supply fans are energized.
6) Do not enable mixed-air control during morning warm-up period.

B. Start and Stop Supply Fan(s):

1. Enable:

a. Input:

1) Device: Smoke detector with auxiliary contact manual reset.
2) Location: Duct mounted before and after supply fan.
3) Location: Mounted in unit.
4) Transference: Starter relay.

b. Output:

1) Device: Hard wired.
2) Location: Motor controller.
3) Transference: Starter relay.

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c. Output Device: Hard wired through motor controller; DDC controller alarm.
d. Action:

1) Allow start if airstream is free of products of combustion.
2) Signal alarm if fan fails to start as commanded.

C. Supply Fan(s) Control:

1. Fan Speed Control:

a. Input:

1) Device: Air pressure transmitter.
2) Location: Supply-duct static pressure referenced to ambient-space static pressure.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Transference: Variable-frequency motor controller.

c. Action:

1) Maintain constant supply-duct static-pressure set point.
2) Set-Point Reset (for Systems with DDC of Individual Zone Terminals): Reset static-pressure set point based on the zone requiring the most pressure; reset set point lower until one zone damper is nearly wide open.
3) Set variable-frequency drive to minimum speed when fan is stopped.

2. Fan Airflow:

a. Input:

1) Device: Airflow sensor.
2) Location: Supply duct.
3) Transference: DDC controller.

b. Output:

1) Device: DDC controller.

c. Action: Report supply-duct airflow.

3. High Pressure:

a. Input:

1) Device: Air pressure switch.
2) Location: Supply duct referenced to outside the duct.
3) Transference: DDC controller.

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b. Output:

1) Device: Binary output; DDC controller.
2) Transference: Starter relay; operator's workstation.

D. Return Fan Control:

1. Fan Speed Control:

a. Input:

1) Device: Airflow sensor.
2) Location: Supply airstream and return airstream.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Variable-frequency drive.
3) Transference: Variable-frequency drive controller.

c. Action:

1) Maintain constant airflow offset between supply- and return-air fans.
2) Set variable-frequency drive to minimum speed when fan is stopped.

2. Fan Speed Control:

a. Input:

1) Device: Air pressure differential transmitter.
2) Location: Indoor space static pressure referenced to outdoor static pressure.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Transference: Variable-frequency motor controller.

c. Action:

1) Maintain constant indoor static-pressure set point of 0.02-inch wg positive for outdoors.
2) Set variable-frequency drive to minimum speed when fan is stopped.

d. Action: Maintain constant indoor static pressure.

3. Discharge-Air Temperature:

a. Input:

1) Device: Air-temperature sensor with air-temperature RTD transmitter.

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2) Location: Discharge airstream.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.

c. Action: Maintain discharge air-temperature set point. See mechanical schedule on record documents for discharge temperature. (adj.)

E. Economizer:

1. ENABLE (Comparative Enthalpy): Outside air (OA) enthalpy shall be compared with Return air (RA) enthalpy point. The economizer shall enable when OA enthalpy is less than RA enthalpy - 2.0 BTU/LB. The economizer shall disable when OA enthalpy is greater than RA enthalpy.

2. OPERATION: The supply air sensor shall measure the dry bulb temperature of the air leaving the evaporator coil while economizing. When economizing is enabled and the unit is operating in the cooling mode, the economizer damper shall modulate between its minimum position and 100% to maintain the space temperature setpoint. Minimum position shall be calculated based on supply fan speed. If the supply air temperature starts to fall below supply air temperature setpoint, the outdoor damper shall be at minimum position. Compressors shall be delayed from operating until the economizer has opened to 100% for 5 minutes.

F. Unit Modes:

1. Occupied: During occupied periods, the supply fan shall run continuously and the mixed air dampers shall open to maintain minimum ventilation requirements. The DX cooling and the gas heat shall control to maintain the active discharge air temperature setpoint. If economizing is enabled, the outdoor air or mixed air dampers shall modulate to maintain the discharge air temperature setpoint and the relief air damper shall track the mixed air dampers. The discharge air temperature setpoint shall be dynamically reset based on the deviation of actual space temperature from the active space temperature setpoint. If the discharge air temperature sensor fails, the DX cooling and the gas heat shall control to maintain the active space temperature setpoint and an alarm shall annunciate at the BAS. If the discharge air temperature sensor and the space temperature sensor fail, the DX cooling shall be disabled, the gas heat shall be disabled, and an alarm shall annunciate at the BAS.

2. Unoccupied: When the space temperature is below the unoccupied heating setpoint of 60.0 deg. F (adj.) the supply fan shall be commanded on, the outside air damper shall remain closed and the gas heat shall be enabled. When the space temperature rises above the unoccupied heating setpoint of 60.0 deg. F (adj.) plus the unoccupied differential of 4.0 deg. F (adj.) the supply fan shall stop and the gas heat shall be disabled. When the space temperature is above the unoccupied cooling setpoint of 85.0 deg. F (adj.) the supply fan shall be commanded on, the outside air damper shall open if economizing is enabled and remain closed if economizing is disabled and the DX cooling shall be enabled. When the space temperature falls below the unoccupied cooling setpoint of 85.0

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deg. F minus the Unoccupied differential of 4.0 deg. F (adj.) the supply fan shall stop, the DX cooling shall be disabled and the outside air damper shall close.

3. Optimal Start: The BAS shall monitor the scheduled occupied time, occupied space setpoints and space temperature to calculate when the optimal start occurs.

4. Morning Warm-Up Mode: During optimal start, if the space temperature is below the occupied heating setpoint a morning warm-up mode shall be activated. When morning warm-up is initiated the unit shall enable the heating and fan(s). The outside air damper shall remain closed. When the space temperature reaches the occupied heating setpoint (adj.), the unit shall transition to the occupied mode.

5. Pre-Cool Mode: During optimal start, if the space temperature is above the occupied cooling setpoint, pre-cool mode shall be activated. When pre-cool is initiated the unit shall enable the fan and cooling or economizer. The outside air damper shall remain closed, unless economizing. When the space temperature reaches occupied cooling setpoint (adj.), the unit shall transition to the occupied mode.

6. Optimal Stop: The BAS shall monitor the scheduled unoccupied time, occupied setpoints and space temperature to calculate when the optimal stop occurs. When the optimal stop mode is active the unit controller shall maintain the space temperature to the space temperature offset setpoint. Outside air damper shall remain enabled to provide minimum ventilation.

7. Occupied Bypass: The BAS shall monitor the status of the ON and CANCEL buttons of the space temperature sensor. When an occupied bypass request is received from a space sensor, the unit shall transition from its current occupancy mode to occupied bypass mode and the unit shall maintain the space temperature to the occupied setpoints (adj.).

8. Heat/Cool Mode: When the space temperature rises above the occupied cooling setpoint the mode shall transition to cooling. When the space temperature falls below the occupied heating setpoint the mode shall transition to heating. When the space temperature is above the occupied cooling setpoint or below the occupied heating setpoint the mode shall remain in its last state. If the space temperature sensor fails the mode shall remain in its last state and an alarm shall annunciate at the BAS. If the local and communicated setpoints fail the controller shall disable the supply fan and an alarm shall annunciate at the BAS.

1.7 SPLIT HEAT PUMP SYSTEMS

A. Split heat pump system shall operate off manufacturer's internal controls.

B. All units shall be provided with BAC net controllers monitored by the BAS.

C. The BAS shall monitor temperature in all spaces conditioned by the heat pump systems. Upon a rise in space temperature above 80º (adj.), an alarm shall be produced at the BAS operators interface detailing the location of the high temperature condition. Upon a drop in space temperature below 60º (adj.), an alarm shall be produced at the BAS operators interface detailing the location of the low temperature condition.

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D. Required monitoring and control points include the following:

1. System Status
2. Condenser Status
3. Evaporator Status
4. Evaporator leaving air temperature.
5. Emergency Electric coil status
6. Space temperature setpoint
7. Actual space temperature
8. High condensate alarms (from internal high-level detectors)
9. Alarms

1.8 ELECTRIC UNIT HEATERS / ELECTRIC WALL HEATERS

A. Electric unit heaters and Electric Wall heaters shall operate to maintain temperature setpoint via remote temperature sensor.

B. Electric and Fire Pump Rooms unit heaters shall be set to maintain a temperature of 55º (adj.).

C. Stairwell wall heaters shall be set to maintain a temperature of 55º (adj.).

D. Required monitoring and control points include the following:

1. Temperature set point
2. Space temperature
3. Fan on/off/alarm
4. Heat on/off

1.9 FANS (F)

A. Fans shall operate continuously.

B. Required monitoring and control points include the following:

1. Fan start and stop.
2. Fan failure

1.10 VRF SYSTEMS

A. The condensing unit shall be tied to the BAS general alarm.

B. The indoor units shall operate through their own integral controls to maintain scheduled mode and temperature setpoint.

C. Refer to unit plan drawings for detailed occupancy sequencing.

D. Required monitoring and control points include the following:
1. System Status
2. Operating mode (based on occupancy)

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3. Condenser Status
4. Evaporator Status
5. Evaporator leaving air temperature.
6. Space temperature setpoint
7. Actual space temperature
8. High condensate alarms (from internal high-level detectors)
9. General Alarms

1.11 DEDICATED OUTDOOR AIR UNITS (DOAS)

A. The ventilation system consists of dedicated outdoor air units, which shall operate based on their packaged internal BACnet controller's sequence to maintain the discharge air temperature setpoint and supply/exhaust duct static pressure setpoints.

B. See mechanical schedule on record documents for discharge temperature. (adj.)

C. Smoke Detection:

1. The unit shall shut down and generate an alarm upon receiving a smoke detector status.
2. All associated smoke dampers and combination fire smoke dampers shall be closed.

D. Outside Air Damper:

1. The outside air damper shall open anytime the unit runs and shall close anytime the unit stops. The supply fan shall start only after the damper status has proven the damper is open. The outside air damper shall close 4 sec. (adj.) after the supply fan stops.
2. Alarms shall be provided as follows:

a. Outside air damper failure: Commanded open, but the status is closed.
b. Outside air damper in hand: Commanded closed, but the status is open.

E. Exhaust Air Damper:

1. The exhaust air damper shall open anytime the unit runs and shall close anytime the unit stops. The exhaust fan shall start only after the damper status has proven the damper is open. The exhaust air damper shall close 4 sec (adj.) after the exhaust fan stops.
2. Alarms shall be provided as follows:

a. Exhaust air damper failure: Commanded open, but the status is closed.
b. Exhaust air damper in hand: Commanded closed, but the status is open.

F. Enthalpy Wheel:

1. The enthalpy wheel shall operate under the unit's integral controller.

2. Alarms shall be provided as follows:

a. Enthalpy Wheel Rotation Failure: Commanded on, but the status is off.
b. Enthalpy Wheel in Hand: Commanded off, but the status is on.

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c. Enthalpy Wheel Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

G. Supply Fan:

1. The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.
2. Volume Control:

   a. Input Device: Static-pressure transmitter in the supply-duct.
   b. Output Device: BAS analog output to motor speed controller.
   c. Action: Maintain constant supply-duct static pressure. Supply static pressure shall be determined during the system air-balancing. Static pressure sensor shall be located 2/3rd downstream of the unit.
   d. Set variable-speed drive to minimum speed when fan is energized. Ramp variable speed drive to minimum speed prior to fan shut down.

3. High Pressure:

   a. Input Device: Static pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
   b. Output Device: BAS binary output to alarm panel and motor starter.
   c. Action: Stop fan and signal alarm when static pressure rises above excessive static-pressure set point.

4. Display and Trending:

   a. Supply-fan-discharge static-pressure indication.
   b. Supply-fan-discharge static-pressure set point.
   c. Supply-fan speed.
   d. High pressure alarm (Greater than 10” w.c.)
   e. Low pressure alarm (Less than 1” w.c.)
   f. VFD Failure alarm.

5. Alarms shall be provided as follows:

   a. Supply Fan Failure: Commanded on, but the status is off.
   b. Supply Fan in Hand: Commanded off, but the status is on.

H. Exhaust Fan:

1. The exhaust fan shall run whenever the supply fan runs.
2. Volume Control: The exhaust fan shall track to an equal air volume of the supply fan.
3. Alarms shall be provided as follows:

   a. Exhaust Fan Failure: Commanded on, but the status is off.
   b. Exhaust Fan in Hand: Commanded off, but the status is on.

L. Supply Air Stream Filter Status:

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1. The controller shall monitor the final filter status. Alarms shall be provided as follows:
2. Supply Filter Change Required: Final filter differential pressure exceeds a user definable limit (adj.).

N. Supply Air Temperature:

1. The controller shall monitor the supply air temperature.
2. Alarms shall be provided as follows:

   a. High Supply Air Temp: If the supply air temperature is greater than 85°F (adj.).
   b. Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

I. Required monitoring and control points are as follows:

1. DDC system graphic.
2. DDC system on-off indication (operating or not operating).
3. DDC system occupied/unoccupied mode.
4. Outdoor-air-temperature indication.
5. Supply-fan on-off indication (operating or not operating).
6. Supply duct static-pressure indication.
7. Supply duct static-pressure set point.
8. Supply-fan airflow rate.
9. Supply-fan speed.
10. Exhaust-fan on-off indication (operating or not operating).
11. Exhaust-fan airflow rate.
12. Exhaust-fan speed.
13. Relative humidity indication.
14. Relative humidity set point.
15. Filter air-pressure-drop indication.
16. Filter low-air-pressure drop set point.
17. Filter high-air-pressure drop set point.
18. Energy recovery supply air temperature inlet and discharge (DB/WB)
19. Energy recovery exhaust air temperature inlet and discharge (DB/WB)
20. Energy recovery supply and exhaust air pressure drop (high/low alarms)

1.12 KITCHEN EXHAUST FANS (GEF)

A. Kitchen exhaust fans shall be interlocked with corresponding exhaust hoods.

B. Required monitoring and control points include the following:

1. Status: ON/OFF
2. General Alarm.

1.13 KITCHEN MAKE-UP AIR UNIT (MAU)

A. The kitchen make-up air unit shall be interlocked with corresponding exhaust hoods and fans to engage the fan and heater when the kitchen exhaust hoods are activated. The Unit shall operate

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based on the packaged internal BACnet controller's sequence to maintain the discharge air temperature setpoint.

B. See mechanical schedule on record documents for discharge air temperature (adj.).

C. Required monitoring and control points include the following:

1. ON/OFF
2. Discharge Temperature
3. High Temperature Alarm: Temperature above 90º (adj.).
4. Low Temperature Alarm: Temperature below 60º (adj.).
5. General Alarm

1.14 EXHAUST FANS (F-1, F-2, F-3, F-10, F-11)

A. Exhaust fans shall operate continuously.

B. Required monitoring and control points include the following:
1. Fan start and stop
2. Fan failure

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION 23 09 93.11

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SECTION 23 23 30

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Refrigerant pipes and fittings.
2. Refrigerant piping valves and specialties.
3. Refrigerants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty.

1. Include pressure drop, based on manufacturer's test data, for the following:

a. Thermostatic expansion valves.
b. Solenoid valves.
c. Hot-gas bypass valves.
d. Filter dryers.
e. Strainers.
f. Pressure-regulating valves.

B. Shop Drawings:

1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
2. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
3. Show interface and spatial relationships between piping and equipment.
4. Shop Drawing Scale: 1/4 inch equals 1 foot.

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1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications." Refrigeration contractor must be certified installer for the installation of refrigerant piping systems and associated specificities required for Variable Refrigerant Flow (VRF) systems.

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K and L.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Brazing Filler Metals: AWS A5.8/A5.8M.

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E. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
4. Working Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.3 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Danfoss Inc.
   b. Heldon Products; Henry Technologies.
   c. Parker Hannifin Corp.
   d. Paul Mueller Company.
   e. Approved Equal.

2. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
3. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
4. Operator: Rising stem and hand wheel.
5. Seat: Nylon.
6. End Connections: Socket, union, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

B. Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Danfoss Inc.
   b. Emerson Climate Technologies.
   c. Heldon Products; Henry Technologies.
   d. Parker Hannifin Corp.
   e. Paul Mueller Company.
   f. Approved Equal.

2. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
3. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
4. Piston: Removable polytetrafluoroethylene seat.
5. Closing Spring: Stainless steel.
6. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
7. End Connections: Socket, union, threaded, or flanged.

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8. Maximum Opening Pressure: 0.50 psig.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 275 deg F.

C. Service Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Danfoss Inc.
   b. Emerson Climate Technologies.
   c. Heldon Products; Henry Technologies.
   d. Parker Hannifin Corp.
   e. Paul Mueller Company.
   f. Refrigeration Sales, Inc.
   g. Approved equal.

2. Body: Forged brass with brass cap including key end to remove core.
3. Core: Removable ball-type check valve with stainless-steel spring.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Copper spring.
6. Working Pressure Rating: 500 psig.

D. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Danfoss Inc.
   b. Emerson Climate Technologies.
   c. Heldon Products; Henry Technologies.
   d. Parker Hannifin Corp.
   e. Paul Mueller Company.
   f. Approved Equal.

2. Body and Bonnet: Plated steel.
3. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Threaded.
6. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 115 V ac coil.
7. Working Pressure Rating: 400 psig.
8. Maximum Operating Temperature: 240 deg F.

E. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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a. Danfoss Inc.
b. Heldon Products; Henry Technologies.
c. Parker Hannifin Corp.
d. Paul Mueller Company.
e. Approved Equal.

2. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
3. Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Threaded.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.

F. Thermostatic Expansion Valves: Comply with AHRI 750.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Danfoss Inc.
b. Emerson Climate Technologies.
c. Heldon Products; Henry Technologies.
d. Paul Mueller Company.
e. Approved Equal.

2. Body, Bonnet, and Seal Cap: Forged brass or steel.
3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Packing and Gaskets: Non-asbestos.
5. Capillary and Bulb: Copper tubing filled with refrigerant charge.
6. Suction Temperature: 40 deg F.
7. Superheat: Adjustable.
8. Reverse-flow option (for heat-pump applications).
9. End Connections: Socket, flare, or threaded union.
10. Working Pressure Rating: 450 psig.

G. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Danfoss Inc.
b. Heldon Products; Henry Technologies.
c. Parker Hannifin Corp.
d. Approved Equal.

2. Body, Bonnet, and Seal Cap: Ductile iron or steel.
3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Packing and Gaskets: Non-asbestos.
5. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
6. Seat: Polytetrafluoroethylene.
7. Equalizer: Internal or External.

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8. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter and 115 V ac coil.
9. End Connections: Socket.
10. Throttling Range: Maximum 5 psig.
11. Working Pressure Rating: 500 psig.
12. Maximum Operating Temperature: 240 deg F.

H. Straight-Type Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Danfoss Inc.
    b. Heldon Products; Henry Technologies.
    c. Parker Hannifin Corp.
    d. Approved Equal.

2. Body: Welded steel with corrosion-resistant coating.
3. Screen: 100-mesh stainless steel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

I. Angle-Type Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Danfoss Inc.
    b. Heldon Products; Henry Technologies.
    c. Parker Hannifin Corp.
    d. Approved Equal.

2. Body: Forged brass or cast bronze.
3. Drain Plug: Brass hex plug.
4. Screen: 100-mesh monel.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

J. Moisture/Liquid Indicators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Danfoss Inc.
    b. Emerson Climate Technologies.
    c. Heldon Products; Henry Technologies.
    d. Parker Hannifin Corp.
    e. Approved Equal.

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2. Body: Forged brass.
3. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
4. Indicator: Color coded to show moisture content in parts per million (ppm).
5. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
6. End Connections: Socket or flare.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

K. Replaceable-Core Filter Dryers: Comply with AHRI 730.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Danfoss Inc.
    b. Emerson Climate Technologies.
    c. Heldon Products; Henry Technologies.
    d. Parker Hannifin Corp.
    e. Approved Equal.

2. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
3. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
4. Desiccant Media: Activated alumina or charcoal.
5. Designed for reverse flow (for heat-pump applications).
6. End Connections: Socket.
7. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
8. Maximum Pressure Loss: 2 psig.
9. Rated Flow: 50 tons.
10. Working Pressure Rating: 500 psig.
11. Maximum Operating Temperature: 240 deg F.

L. Permanent Filter Dryers: Comply with AHRI 730.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Danfoss Inc.
    b. Emerson Climate Technologies.
    c. Heldon Products; Henry Technologies.
    d. Parker Hannifin Corp.
    e. Approved Equal.

2. Body and Cover: Painted-steel shell.
3. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
4. Desiccant Media: Activated alumina or charcoal.
5. Designed for reverse flow (for heat-pump applications).
6. End Connections: Socket.
7. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.

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8. Maximum Pressure Loss: 2 psig.
9. Rated Flow: 50 tons.
10. Working Pressure Rating: 500 psig.
11. Maximum Operating Temperature: 240 deg F.

M. Mufflers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Danfoss Inc.
    b. Emerson Climate Technologies.
    c. Heldon Products; Henry Technologies.
    d. Approved Equal.

2. Body: Welded steel with corrosion-resistant coating.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

N. Receivers: Comply with AHRI 495.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Heldon Products; Henry Technologies.
    b. Approved Equal.

2. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
3. Comply with UL 207; listed and labeled by an NRTL.
4. Body: Welded steel with corrosion-resistant coating.
5. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
6. End Connections: Socket or threaded.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

O. Liquid Accumulators: Comply with AHRI 495.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Emerson Climate Technologies.
    b. Heldon Products; Henry Technologies.
    c. Parker Hannifin Corp.
    d. Approved Equal.

2. Welded steel with corrosion-resistant coating.
3. End Connections: Socket or threaded.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

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2.4 REFRIGERANTS

A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arkema Inc.
b. DuPont Fluorochemicals Div.
c. Genetron Refrigerants; Honeywell International Inc.
d. Mexichem Fluor Inc.
e. Approved Equal.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Hot-Gas and Liquid Lines, and Suction Lines for Heat Pump Applications:

1. NPS 5/8 and Smaller: Copper, Type L (B), annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
2. NPS 3/4 to NPS 1 and Smaller: Copper, Type K (A), annealed or drawn-temper tubing and wrought-copper fittings with brazed joints.
3. NPS 1-1/4 and Smaller: Copper, Type L (B), drawn-temper tubing and wrought-copper fittings.

B. Safety-Relief-Valve Discharge Piping: Copper, Type L (B), annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping: Copper, Type L (B), drawn-temper tubing and wrought-copper fittings.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install a full-size, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

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G. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of VRF equipment and refrigerant piping systems. Refrigeration piping arrangements, piping footages and sizing were supplied by the Basis of Design VRF manufacturer. The refrigeration contractor shall be responsible for coordinating refrigerant piping design, routing and sizing based on the VRF equipment/systems submitted. The refrigeration contractor must be a factory trained and certified installer of the VRF equipment submitted. Install piping systems as indicated on the approved refrigeration shop drawing, and do not make any field deviations to layout unless approved by the VRF manufacturer.

B. Install refrigerant piping according to ASHRAE 15 and per manufacturers' recommendations.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

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F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in architectural division of the specification if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

O. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

P. Before installation of refrigerant piping, clean pipe and fittings using the following procedures:

1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lint less cloth through tubing by means of a wire or electrician's tape.
3. Draw a clean, lint less cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. Draw a clean, lint less cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lint less cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

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Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

E. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and to restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

G. Welded Joints: Construct joints according to AWS D10.12M/D10.12.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

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3.5 HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:

1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod, 3/8 inch.

D. Support multi floor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.

a. Purge all refrigerant lines before testing.
b. Fill system with nitrogen to the required test pressure.
c. System shall maintain test pressure at the manifold gage throughout duration of test.
d. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
e. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports as required to maintain VRF system warranties and as outlined on the manufacturers' checklist.

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C. Coordinate with the manufacturer's representative to be present multiple times during construction to witness and inspect the installation of refrigerant piping.

D. Submit refrigeration piping "as built" drawings along with all test reports at project completion.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Charge per manufacturer's recommendations.
2. Install core in filter dryers after leak test but before evacuation.
3. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
4. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
5. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 23 23 00

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SECTION 23 31 13

METAL DUCTS

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

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1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

PART 2 - PRODUCTS

2.1 SINGLE-WALL GREASE DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Guidelines" and HVAC Duct Construction Standards – Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Construct concealed kitchen range hood exhaust ducts, including the plenum, to and through the roof, and the ductwork on the outlet side of the fan of minimum No. 18 gage Type 304 stainless steel.

C. Seams and joints shall be externally welded liquid tight using the Carbon Arc Process.

D. Single-wall grease duct shall be wrapped with fire-rated insulation in accordance with Specification 230713 "Duct Insulation".

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2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Ductmate Industries, Inc.
    b. Lindab Inc.
    c. McGill AirFlow LLC.
    d. SEMCO LLC.
    e. Approved Equal.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 in Diameter: Flanged.

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C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: Black.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

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G. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

H. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.5 DUCT LINER

A. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Aeroflex USA, Inc.
b. Armacell LLC.
c. Approved Equal.

2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

a. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

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3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

    a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.6 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C 920.

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1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

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PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

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C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease and sloped a minimum of 2 percent to drain grease back to the hood.

B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet or as required by code in horizontal ducts, or as indicated on Drawings.

C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. All ductwork shall be sealed to Seal Class A.
3. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class A.
4. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
5. Unconditioned Space, Exhaust Ducts: Seal Class A.
6. Unconditioned Space, Return-Air Ducts: Seal Class A.
7. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class A.
8. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
9. Conditioned Space, Exhaust Ducts: Seal Class A.
10. Conditioned Space, Return-Air Ducts: Seal Class A.

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3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in the architectural sections of the specifications.

3.8 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

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3.9 DUCT SCHEDULE

A. Supply Ducts:

1. Ducts Connected to Fan Coil Units:

a. Pressure Class: Positive 1-inch wg.
b. Minimum SMACNA Seal Class: A
c. SMACNA Leakage Class for Rectangular: 3 1%.
d. SMACNA Leakage Class for Round 3 1%.

2. Ducts Connected to Constant-Volume Air-Handling Units:

a. Pressure Class: Positive 1-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 3 1%.
d. SMACNA Leakage Class for Round: 3 1%.

3. Ducts Connected to Variable-Air-Volume Air-Handling Units:

a. Pressure Class: Positive 3-inch wg.
b. Minimum SMACNA Seal Class: A
c. SMACNA Leakage Class for Rectangular: 3 1%
d. SMACNA Leakage Class for Round: 3 1%.

4. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 3 1%.
d. SMACNA Leakage Class for Round: 3 1%.

B. Return Ducts:

1. Ducts Connected to Fan Coil Units:

a. Pressure Class: Positive or negative 1-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 3 1%.
d. SMACNA Leakage Class for Round: 3 1%.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 3 1%.
d. SMACNA Leakage Class for Round: 3 1%.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.

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c. SMACNA Leakage Class for Rectangular: 3 1%.
d. SMACNA Leakage Class for Round: 3 1%.

C. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 3 1%.
d. SMACNA Leakage Class for Round: 3 1%.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 3 1%.
d. SMACNA Leakage Class for Round: 3 1%.

3. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.

a. Concealed: 16 gauge carbon steel.
b. Welded seams and joints.
c. Pressure Class: Positive or negative 2-inch wg.
d. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
e. SMACNA Leakage Class: 3 1%.

4. Ducts Connected to Dishwasher Hoods:

a. Type 304, stainless-steel sheet.
b. Concealed: No. 2D finish.
c. Welded seams and flanged joints with watertight EPDM gaskets.
d. Pressure Class: Positive or negative 2-inch wg.
e. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
f. SMACNA Leakage Class: 3 1%.

5. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 3-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 3 1%.

D. Outdoor Ducts:

1. Ducts Connected to Fan Coil Units:

a. Pressure Class: Positive or negative 1-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 3 1%.
d. SMACNA Leakage Class for Round: 3 1%.

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2. Ducts Connected to Air-Handling Units:

    a. Pressure Class: Positive or negative 1-inch wg.
    b. Minimum SMACNA Seal Class: A.
    c. SMACNA Leakage Class for Rectangular: 3 1%.
    d. SMACNA Leakage Class for Round: 3 1%.

3. Ducts Connected to Equipment Not Listed Above:

    a. Pressure Class: Positive or negative 2-inch wg.
    b. Minimum SMACNA Seal Class: A.
    c. SMACNA Leakage Class for Rectangular: 3 1%.
    d. SMACNA Leakage Class for Round: 3 1%.

E. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
2. Aluminum Ducts: Aluminum.

F. Liner:

1. Supply Air Ducts: Flexible elastomeric, 1 inch thick.
2. Return Air Ducts: Flexible elastomeric, 1 inch thick.
3. Exhaust Air Ducts: Flexible elastomeric, Type I, 1 inch thick.
4. Supply Fan Plenums: Flexible elastomeric, 1 inch thick.
5. Return and Exhaust-Fan Plenums: Flexible elastomeric, 2 inches thick.
6. Transfer Ducts: Flexible elastomeric, ½" inch thick.

G. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Velocity 1000 fpm or Lower:

        1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
        2) Mitered Type RE 4 without vanes.

    b. Velocity 1000 to 1500 fpm:

        1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
        2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
        3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

    c. Velocity 1500 fpm or Higher:

        1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

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2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

H. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Spin in.

2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm: Conical tap.
c. Velocity 1500 fpm or Higher: 45-degree lateral.

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END OF SECTION 23 31 13

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SECTION 23 33 00

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. Backdraft dampers.
2. Manual volume dampers.
3. Fire dampers.
4. Fire/Smoke dampers.
5. Flange connectors.
6. Turning vanes.
7. Duct-mounted access doors.
8. Flexible connectors.
9. Flexible ducts.
10. Duct accessory hardware.

B. Related Requirements:

1. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances, and method of field assembly into duct systems and other construction. Include the following:

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a. Special fittings.
b. Manual volume damper installations.
c. Fire-damper and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
d. Wiring Diagrams: For power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

C. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Fan Corporation.

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2. Nailor Industries Inc.
3. Pottorff.
4. Ruskin Company.
5. Approved Equal.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 1000 fpm

D. Maximum System Pressure: 1-inch w.g.

E. Frame: Hat-shaped, 0.05-inch-thick, galvanized sheet steel 0.094-inch-thick, with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, end pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum noncombustible, with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:

1. Material: Galvanized steel
2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball or synthetic pivot bushings.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.
    a. Sleeve Thickness: 20 gage minimum.
    b. Sleeve Length: 6 inches minimum.
6. Screen Mounting: Rear mounted.
7. Screen Material: Galvanized steel.
8. Screen Type: Insect.
9. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Nailor Industries Inc.
    b. Pottorff.
    c. Ruskin Company.
    d. Vent Products Co., Inc.
    e. Approved Equal.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames:

    a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel.
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized-steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel.
7. Bearings:

    a. Oil-impregnated bronze.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

2.5 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Pottorff.
2. Prefco.
3. Ruskin Company.
4. Approved Equal.

B. Type: Static; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 3-inch wg static pressure class and minimum 2000-fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

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F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.05 thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.024-inch thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

K. Heat-Responsive Device: replaceable link and switch package, factory installed, 165 deg F rated.

2.6 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cesco Products; a divsion of MESTEK, Inc.
2. Nailor Industries Inc.
3. Pottorff.
4. Ruskin Company.
5. Approved Equal.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 3-inch wg static pressure class and minimum 2000-fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded interlocking, corners and mounting flange.

F. Heat-Responsive Device: Resettable, 165 deg F rated, fusible links fire-closure device.

G. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.

H. Smoke Detector: Integral, factory wired for single-point connection.

I. Blades: Roll-formed, horizontal, interlocking, 0.063-inch thick, galvanized sheet steel.

J. Leakage: Class I.

K. Rated pressure and velocity to exceed design airflow conditions.

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L. Mounting Sleeve: Factory-installed, 0.039-inch thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

M. Master control panel for use in dynamic smoke-management systems.

N. Damper Motors: two-position action.

O. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Motors in Outdoor Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

P. Accessories:

1. Auxiliary switches for signaling fan control or position indication.
2. Test and reset switches.

2.7 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Hardcast, Inc.
4. Ward Industries; a brand of Hart & Cooley, Inc.
5. Approved Equal.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

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D. Gage and Shape: Match connecting ductwork.

2.8 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aero-Dyne Sound Control Co.
2. Ductmate Industries, Inc.
3. Duro Dyne Inc.
4. Hardcast, Inc.
5. Ward Industries; a brand of Hart & Cooley, Inc.
6. Approved Equal.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

D. Vane Construction: Single or Double wall.

E. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.9 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cesco Products; a divsion of MESTEK, Inc.
2. Ductmate Industries, Inc.
3. Nailor Industries Inc.
4. Pottorff.
5. Ward Industries; a brand of Hart & Cooley, Inc.
6. Approved Equal.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.

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d. Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.10 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
2. Ductmate Industries, Inc.
3. Flame Gard, Inc.
4. Approved Equal.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.11 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Duro Dyne Inc.
2. Ductmate Industries, Inc.
3. Elgen Manufacturing.
4. Ventfabrics, Inc.
5. Approved Equal.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

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D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

2.12 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Ward Industries; a brand of Hart & Cooley, Inc.
4. Approved Equal.

B. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.
4. Insulation R-value: 6.

C. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.
2. Non-Clamp Connectors: Adhesive plus sheet metal screws.

2.13 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

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PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot spacing.
8. Upstream and downstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.

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2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

N. Connect diffusers to ducts directly with maximum 60-inch lengths of flexible duct clamped or strapped in place.

O. Connect flexible ducts to metal ducts with draw bands plus sheet metal screws.

P. Install duct test holes where required for testing and balancing purposes.

Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

END OF SECTION 23 33 00

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SECTION 23 34 16

CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. Forward-curved centrifugal fans.

1.4 ACTION SUBMITTALS

A. Product Data:

1. Include rated capacities, furnished specialties, and accessories for each fan.
2. Certified fan performance curves with system operating conditions indicated.
3. Certified fan sound-power ratings.
4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
5. Material thickness and finishes, including color charts.
6. Dampers, including housings, linkages, and operators.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

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1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. AMCA Compliance:

1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
2. Operating Limits: Classify according to AMCA 99.

B. Unusual Service Conditions:

1. Ambient Temperature: 95 deg F.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Capacities and Characteristics:

1. Refer to schedule on the drawings for capacities and characteristics.
2. Vibration Isolators: Spring isolators having a static deflection of 1-inch deflection.

2.2 FORWARD-CURVED CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck.
2. Breidert Air Products.
3. Loren Cook Co.
4. Penn/Barry.
5. Approved Equal.

B. Description:

1. Factory-fabricated, assembled, tested, and finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.

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2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. Housings:

1. Formed panels to make curved-scroll housings with shaped cutoff.
2. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
3. Horizontally split, bolted-flange housing.
4. Spun inlet cone with flange.
5. Outlet flange.

D. Forward-Curved Wheels:

1. Black-enameled or galvanized-steel construction with inlet flange, backplate, shallow blades with inlet and tip curved forward in direction of airflow.
2. Mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

E. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Prelubricated and Sealed Shaft Bearings:

1. Self-aligning, pillow-block-type ball bearings.
2. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours.

G. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
2. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours.

H. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: 1.5.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 25 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.

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6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

I. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Discharge Dampers: Assembly with parallel blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
8. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

J. Capacities and Characteristics:

1. Refer to schedule on the drawings for capacities and characteristics.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration Controls for HVAC."

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E. Curb Support: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," Low-Slope Membrane Roofing Construction Details Section, Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install and secure centrifugal fans on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.

F. Unit Support: Install centrifugal fans level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

G. Isolation Curb Support: Install centrifugal fans on isolation curbs and install flexible duct connectors and vibration isolation.

1. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.
2. Comply with requirements in Section 230548 "Vibration Controls for HVAC" for vibration isolation devices.

H. Install units with clearances for service and maintenance.

I. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.3 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 23 34 16

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SECTION 23 34 23

HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. Utility set fans.
2. Centrifugal roof ventilators.
3. In-line centrifugal fans.
4. Propeller fans.

1.4 PERFORMANCE REQUIREMENTS

A. Operating Limits: Classify according to AMCA 99.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

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1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set for each belt-driven unit.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 UTILITY SET FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Corporation

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2. Loren Cook Company.
3. Peerless Blowers.
4. Penn/Barry.
5. Approved Equal.

B. Housing: Fabricated of galvanized steel with side sheets fastened with a deep lock seam or welded to scroll sheets.

1. Housing Discharge Arrangement: Adjustable to eight standard positions.

C. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.

1. Blade Materials: Steel and Aluminum.
2. Blade Type: Backward inclined, forward curved or Airfoil.

D. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

E. Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L_{50} of 200,000 hours.

1. Extend grease fitting to accessible location outside of unit.

F. Belt Drives:

1. Factory mounted, with final alignment and belt adjustment made after installation
2. Service Factor Based on Fan Motor Size: 1.5
3. Motor Pulleys: Adjustable pitch for use with motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
5. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

G. Accessories:

1. Inlet and Outlet: Flanged.
2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
3. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades with felt edges in steel frame installed on fan discharge.
4. Access Door: Gasketed door in scroll with latch-type handles.
5. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
6. Inlet Screens: Removable wire mesh.
7. Drain Connections: NPS 3/4 threaded coupling drain connection installed at lowest point of housing.
8. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
9. Discharge Dampers: Assembly with parallel blades constructed of two plates formed around and to shaft, channel frame, sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
10. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.

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11. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

H. Capacities and Characteristics:

1. Refer to schedule on the drawings for capacities and characteristics.
2. Vibration Isolators:

a. Type: Spring isolators.

2.2 CENTRIFUGAL ROOF VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Fan Corporation.
2. Breidert Air Products.
3. Loren Cook Company.
4. Penn/Barry.
5. Approved equal.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle, one-piece, aluminum base with venturi inlet cone.

1. Up-blast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum, or brass wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

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F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in raised cant and mounting flange.
2. Overall Height: 12 inches.
3. Metal Liner: Galvanized steel.
4. Vented Curb: Unlined with louvered vents in vertical sides.

G. Capacities and Characteristics:

1. Refer to schedule on the drawings for capacities and characteristics.

2.3 IN-LINE CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Fan Corporation

2. Breidert Air Products.
3. Loren Cook Company.
4. Penn/Barry.
5. Approved Equal.

B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

D. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

E. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
3. Companion Flanges: For inlet and outlet duct connections.
4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

F. Capacities and Characteristics:

1. Refer to schedule on the drawings for capacities and characteristics.
2. Vibration Isolators:

a. Type: Elastomeric hangers.

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2.4 PROPELLER FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Fan Corporation

2. Breidert Air Products.
3. Loren Cook Company.
4. Penn/Barry.
5. Approved Equal.

B. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.

C. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.

D. Fan Wheel: Replaceable, cast extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

E. Fan Drive: Motor mounted in airstream; factory wired to disconnect switch located on outside of fan housing.

F. Fan Drive:

1. Resiliently mounted to housing.
2. Statically and dynamically balanced.
3. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
4. Extend grease fitting to accessible location outside of unit.
5. Service Factor Based on Fan Motor Size: 1.4.
6. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
7. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

   a. Ball-Bearing Rating Life: ABMA 9, L_{10} of 100,000 hours.

8. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
9. Motor Pulleys: Adjustable pitch for use with motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
10. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
11. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

G. Accessories:

1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Weather Shield Front Guard: Galvanized steel with expanded metal screen.

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5. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
6. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

H. Capacities and Characteristics:

1. Refer to schedule on the drawings for capacities and characteristics.
2. Vibration Isolators:

a. Type: Elastomeric hangers.

2.5 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Enclosure Type: Totally enclosed, fan cooled.

2.6 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Equipment Mounting:

C. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.

D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

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E. Support suspended units from structure using threaded steel rods and elastomeric hangers having a static deflection of 1 inch. Vibration-control devices are specified in Section 230548 "Vibration Control for HVAC."

F. Install units with clearances for service and maintenance.

G. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to the electrical division of the specifications.

D. Connect wiring according to the electrical division of the specifications.

3.3 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 23 34 23

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SECTION 23 37 13

GRILLES, REGISTERS AND DIFFUSERS

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Refer to drawing schedules for grille, register and diffuser types and accessories.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire dampers and volume-control dampers not integral to diffusers.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static pressure drop, and noise ratings.
2. Grille and Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 GRILLES REGISTERS AND DIFFUSERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Titus

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2. Krueger.
3. Nailor Industries Inc.
4. Price Industries.
5. Approved equal.

2.2 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install grilles, registers and diffusers level and plumb.

B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install grilles, registers and diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire/smoke dampers.

3.2 ADJUSTING

A. After installation, adjust grilles, registers and diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13

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SECTION 23 74 13

PACKAGED ROOFTOP UNITS

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PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:

1. Supply air fan
2. Direct-expansion cooling.
3. Gas heating furnace.
4. Economizer outdoor- return- and relief air damper section.
5. Packaged controls

1.4 DEFINITIONS

A. DDC: Direct-digital controls.

B. ECM: Electrically commutated motor.

C. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

D. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

E. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

F. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating

operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

1.5 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of unit to existing curb. Indicate coordinating requirements with roof membrane system.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One set for belt-driven fan.
2. Filters: Two set of filters.

1.8 QUALITY ASSURANCE

A. ARI Compliance:

1. Comply with ARI 203/110 and ARI 303/110 for testing and rating energy efficiencies for RTUs.
2. Comply with ARI 270 for testing and rating sound performance for RTUs.

B. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

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C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

E. UL Compliance: Comply with UL 1995.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Trane
2. Carrier Corporation; a unit of United Technologies Corp.
3. Aaon.
4. JCI/York
5. Approved Equal.

B. When providing equipment from manufacturer other than basis of design, contractor is responsible for providing all modifications to existing curb, curb adaptors, modifications to existing supply and return ductwork being connected to and all other modifications necessary to accommodate equipment other than the basis of design.

2.2 CASING

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

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B. Exterior Casing Material: 18-gage Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

C. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

1. Materials: ASTM C 1071, Type I.
2. Thickness: 3/4 inch.
3. Density: 2.0 lbs; R-13.
4. Liner materials shall have air-stream surface coated with an erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
5. Liner Adhesive: Comply with ASTM C 916, Type I.

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.3 FANS

A. Fan Drives:

1. Unit shall be equipped with variable frequency drive (VFD) inverter. The VFD shall be installed inside the unit cabinet and shall be factory-mounted, wired and tested. The VFD shall control motor speed to maintain set point static pressure at the sensor tube location of the supply duct pressure transducer (transducer is factory-provided and installed; sensor tube must be field-routed). The control system may be field adjusted to maintain supply duct static pressure set points. The variable frequency drive shall include the following features:

a. Full digital control with direct control from the unit controls.
b. Insulated Gate Bi-Polar Transistors (IGBT) used to produce the output pulse width modulated (PWM) waveform, allowing for quiet motor operation.
c. Inverters capable of operation at a frequency of 8 kHz, so no acoustic noise shall be produced by the motor.
d. Self-diagnostics.
e. Personal lockout code for additional security.
f. Critical frequency avoidance.
g. RS485 capability standard.
h. Electronic thermal overload protection.
i. 5% swinging chokes for harmonic reduction and improved power factor.
j. All printed circuit boards shall be conformal coated.

B. Indoor Supply Fans:

1. Direct drive, unhoused, backward curved, plenum supply fans.
2. Fan shaft bearings shall be of the pillow block type with positive locking collar and lubrication provisions.
3. Statically and dynamically balanced.
4. Fan shaft bearings shall have a life of 200,000 hours at design operating conditions in accordance with ANSI B3.15.
5. Solid fan shaft construction for nominal 40-ton units and two-piece solid fan shaft construction on the nominal unit 60-ton unit.

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C. Condenser-Coil Fan:

1. Fans shall be direct-driven propeller type only, with corrosion-resistant blades riveted to corrosion resistant steel supports for all nominal 40=ton size units. Nominal 60-ton size units with the microchannel condenser coil shall have a direct driven, 9-blade airfoil cross section, reinforced polymer construction, and shrouded-axial type fans with inherent corrosion resistance.
2. Discharge air vertically upward and protected by PVC coated steel wire safety guards.
3. Statically and dynamically balanced.

D. Modulating Power Exhaust Fan: Belt driven, unhoused, backward curved, plenum type.

2.4 COILS

A. Supply-Air Refrigerant Coil:

1. Aluminum plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Coil Split: Interlaced.
4. Condensate Drain Pan: Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1.

B. Gas-Fired Furnace Heating:

a. Heat-Transfer Rate: As scheduled.
b. Entering-Air Temperature: As scheduled.
c. Leaving-Air Temperature: As scheduled.
d. Efficiency: 80 percent.
e. Fuel: Natural gas.
f. Gas Heating Value: As scheduled.
g. Gas Input: As scheduled.
h. Gas Burner Electrical Characteristics:

1) Power Input: As scheduled.
2) Volts: 460.
3) Phase: Three.
4) Hertz: 60.
5) Full-Load Amperes: As scheduled.
6) Minimum Circuit Ampacity: As scheduled.
7) Maximum Overcurrent Protection: As scheduled.

2.5 REFRIGERANT CIRCUIT COMPONENTS

A. Number of Refrigerant Circuits: Two.

B. Compressors: Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

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C. Variable Capacity Compressor: Hermetic, digital scroll on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief and crankcase heater.

D. Refrigeration Specialties:

1. Refrigerant: R-410A
2. Expansion valve with replaceable thermostatic element.
3. Solid core refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.

2.6 INDIRECT FIRED GAS FURNACE HEATING

A. Furnace Assembly:

1. Factory assembled, piped, and wired.
2. Comply with requirements in NFPA 54, "National Fuel Gas Code"; ANSI Z83.4, "Non-Recirculating Direct Gas-Fired Industrial Air Heaters"; and ANSI Z83.18, "Recirculating Direct Gas-Fired Industrial Air Heaters."

B. Burners:

1. Cast-iron burner with stainless-steel mixing plates.
2. Rated for a maximum turndown ratio of 30:1.
3. Fuel: Natural gas.

C. Safety Controls:

1. Gas manifold safety switches and controls shall comply with ANSI standards IRI.
2. Pilot: Intermittent spark igniter.
3. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
4. External gas-pressure regulator shall regulate pressure to not more than 0.5 psig.
5. Airflow Proving Switch: Dual pressure switch senses correct airflow before energizing pilot and requires airflow to be maintained within minimum and maximum pressure settings across burner.
6. Manual-Reset, High-Limit Switch: Stops burner and closes main gas valve if high-limit temperature is exceeded.
7. Gas Train: Redundant main gas valves, electric pilot valve, main and pilot gas-pressure regulators, main and pilot manual shutoff valves, high-low gas-pressure switches, and main and pilot pressure taps, to comply with IRI requirements.

2.7 AIR FILTRATION

A. Extended-Surface, Disposable Panel Pre-Filters and Filters:

1. Comply with NFPA 90A.
2. Factory-fabricated, dry, extended-surface type.

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3. Thickness: 2 inches.
4. Minimum Arrestance: 90, according to ASHRAE 52.1.
5. Minimum MERV: 8, according to ASHRAE 52.2.
6. Thickness: 4 inches.
7. Minimum Arrestance: 90, according to ASHRAE 52.1.
8. Minimum MERV: 13, according to ASHRAE 52.2.
9. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent and held by self-supporting wire grid.

B. Mounting Frames:

1. Extended surface filters arranged for flat orientation, removable from access plenum.
2. Galvanized or stainless steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter.

2.8 DAMPERS

A. Outdoor-Air Damper: Linked damper blades, for 0 to 100 percent outdoor air, with motorized damper filter.

B. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.

1. Damper Motor: Modulating with adjustable minimum position.
2. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IESNA 90.1, with bird screen and hood.

C. Ultra-Low Leak Economizer:

1. Differential enthalpy controlled integrated type consisting of dampers, actuator, and linkages in conjunction with control system to provide primary cooling using outdoor air, conditions permitting, supplemented with mechanical cooling when necessary.
2. a. Economizer shall meet the requirements of the California Energy Commission Title 24 economizer requirements.
3. b.Dampers shall be a gear driven ultra-low leakage type with blade and edge seals. Dampers shall exhibit a maximum leakage rate of 3 cfm per square foot of area at 1 in. wg pressure differential when tested in accordance with AMCA (Air Movement and Control Association) Standard 500.
4. Airflow Measurement:

a. Monitoring System: Complete and functioning system of airflow monitoring as an integral part of the damper assembly where indicated.
b. Remote Monitoring Signal: 0-10 volt or 4-20 mA scaled signal.
c. Accuracy of flow measurement: Within 10 percent of the actual flow rate between the range of the scheduled minimum and maximum airflow. For units with a large range between minimum and maximum airflow, configure the damper sections and flow measurement assembly as necessary to comply with accuracy.
d. Straightening Device: Integral to the flow measurement assembly if required to achieve the specified accuracy as installed.

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e. flow measuring device: Suitable for operation in untreated and unfiltered outdoor air. If necessary, include temperature and altitude compensation and correction to maintain the accuracy.

2.9 ELECTRICAL POWER CONNECTION

A. Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.10 CONTROLS

A. Provide manufacturer's packaged controller capable of sequencing all unit operations. The controller shall communicate with building's BacNet control system. Coordinate protocol and provide communications interface accordingly.

B. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide building management system compatible interface for central HVAC control workstation for the following:

a. Adjusting set points.
b. Monitoring supply fan start, stop, and operation.
c. Modulate supply and power exhaust fans.
d. Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
e. Monitoring occupied and unoccupied operations.
f. Monitoring variable motor loads.
g. Monitoring variable-frequency drive operation.
h. Monitoring cooling load.
i. Monitoring economizer cycles.
j. Monitoring air-distribution static pressure and ventilation air volume.

C. Furnace Controls:

1. Factory-mounted sensor in supply outlet with sensor adjustment located in control panel to modulate gas furnace burner to maintain space temperature.
2. Electromechanical or Electronic Burner Control: 20 to 100 percent modulation of the firing rate.

2.11 ACCESSORIES

A. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

B. Coil guards of painted, galvanized-steel wire.

C. Hail guards of galvanized steel.

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D. Vibration isolation rails.

E. Non-fused disconnect switch.

F. Roof Curb: Full-perimeter plenum curb of sheet metal, minimum 24 inches high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.

1. Comply with requirements in "The NRCA Roofing Manual."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Roof Curb: Provide and install vibration isolation rails, set on plenum roof curb, level and secure. Secure RTUs to upper curb rail, and secure curb base to roof framing.

B. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

C. Comply with requirements for gas-fired furnace installation in NFPA 54, "National Fuel Gas Code."

3.3 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

B. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.

C. Gas Piping Connections:

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1. Comply with requirements in Section 231123 "Natural-Gas Piping."
2. Connect gas piping to furnace, full size of gas train inlet, and connect with union, pressure regulator, and shutoff valve with sufficient clearance for burner removal and service.
3. Install AGA-approved flexible connectors.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Report results in writing.

C. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, coils, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean condenser coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.
12. Remove packing from vibration isolators.
13. Inspect operation of barometric relief dampers.
14. Verify lubrication on fan and motor bearings.

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15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
16. Adjust fan belts to proper alignment and tension.
17. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.

18. Inspect and record performance of interlocks and protective devices; verify sequences.
19. Operate unit for an initial period as recommended or required by manufacturer.
20. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.

    a. Measure gas pressure on manifold.
    b. Inspect operation of power vents.
    c. Measure combustion-air temperature at inlet to combustion chamber.
    d. Measure flue-gas temperature at furnace discharge.
    e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

21. Calibrate thermostats.
22. Adjust and inspect high-temperature limits.
23. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
24. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.

26. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

27. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

    a. High-temperature limit on gas-fired heat exchanger.
    b. Low-temperature safety operation.
    c. Filter high-pressure differential alarm.
    d. Economizer to minimum outdoor-air changeover.
    e. Relief-air fan operation.

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f. Smoke alarms.

28. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain RTU.

END OF SECTION 23 74 13

NOT FOR BIDDING PURPOSES

SECTION 23 74 33

DEDICATED OUTDOOR-AIR UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes factory-packaged units capable of supplying up to 100 percent outdoor air and providing cooling and heating.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Prepare the following by or under the supervision of a qualified professional engineer:

    a. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
    b. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For units to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One sets for each belt-driven fan.
2. Filters: One set for each unit.

NOT FOR BIDDING PURPOSES

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Trane
2. AAON.
3. Addison.
4. Desert Aire.
5. Munters Corporation.
6. JCI/York
7. Approved Equal.

2.2 PERFORMANCE REQUIREMENTS

A. General Fabrication Requirements: Comply with requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."

B. Cabinet Thermal Performance:

1. Maximum Overall U-Value: Comply with requirements in ASHRAE/IESNA 90.1.
2. Include effects of metal-to-metal contact and thermal bridges in the calculations.

C. Cabinet Surface Condensation:

1. Cabinet shall have additional insulation and vapor seals if required to prevent condensation on the interior and exterior of the cabinet.
2. Portions of cabinet located downstream from the cooling coil shall have a thermal break at each thermal bridge between the exterior and interior casing to prevent condensation from occurring on the interior and exterior surfaces. The thermal break shall not compromise the structural integrity of the cabinet.

D. Maximum Cabinet Leakage: 0.5 percent of the total supply-air flow at a pressure rating equal to the fan shut-off pressure.

E. Cabinet Deflection Performance:

1. Walls and roof deflection shall be within 1/200 of the span at the design working pressure equal to the fan shut-off pressure. Deflection limits shall be measured at any point on the surface.

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2. Floor deflections shall be within 1/240 of the span considering the worst-case condition caused by the following:

    a. Service personnel.
    b. Internal components.
    c. Design working pressure defined for the walls and roof.

F. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Refer to schedules on the drawings for capacities and characteristics.

2.3 CABINET

A. Construction: double wall.

B. Exterior Casing Material: Galvanized steel with paint finish.

C. Interior Casing Material: Galvanized steel.

D. Lifting and Handling Provisions: Factory-installed shipping skids and lifting lugs.

E. Base Rails: Galvanized-steel rails for mounting on roof curb or pad as indicated.

1. Service Doors: Hinged access doors with gaskets. Material and construction of doors shall match material and construction of cabinet in which doors are installed.

F. Roof: Standing seam or membrane; sloped to drain water.

G. Floor: Reinforced, metal surface; reinforced to limit deflection when walked on by service personnel. Insulation shall be below metal walking surface.

H. Cabinet Insulation:

1. Type: Fibrous-glass duct lining complying with ASTM C 1071, Type II or flexible elastomeric insulation complying with ASTM C 534, Type II, sheet materials.
2. Thickness: 1 inch.
3. Insulation Adhesive: Comply with ASTM C 916, Type I.
4. Mechanical Fasteners: Suitable for adhesive, mechanical, or welding attachment to casing without damaging liner and without causing air leakage when applied as recommended by manufacturer.

I. Condensate Drain Pans:

1. Shape: Rectangular, with 1 percent slope in at least two planes to direct water toward drain connection.
2. Size: Large enough to collect condensate from cooling coils including coil piping connections, coil headers, and return bends.
3. Configuration: Double wall, with space between walls filled with foam insulation and moisture-tight seal.

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4. Material: Galvanized-steel sheet with asphaltic waterproofing compound coating on pan top surface.
5. Material: Stainless-steel sheet.
6. Drain Connection:

    a. Located on one end of pan, at lowest point of pan.
    b. Terminated with threaded nipple.
    c. Minimum Connection Size: NPS 1.

7. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

J. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1 for resistance to mold and erosion.

K. Roof Curb: Full-perimeter plenum roof curb of sheet metal, minimum 24 inches high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.

1. Comply with requirements in "The NRCA Roofing Manual."

2.4 SUPPLY FAN

A. Plenum Fan Type: Single width, non-overloading, with backward-inclined or airfoil blades.

1. Fan Wheel Material: Aluminum; attached directly to motor shaft.
2. Fan Wheel Drive and Arrangement: Direct drive, AMCA Arrangement 4.
3. Fan panel and frame Material: Powder-coated steel, stainless steel, or aluminum.
4. Fan Enclosure: Easily removable enclosure around rotating parts.
5. Fan Balance: Precision balance fan below 0.08 inch/s at design speed with filter in.

B. Service Factor for Belt Drive Applications: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly with minimum 1.4 service factor.

C. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: Open drip proof.
3. Enclosure Materials: Cast iron.
4. Efficiency: Premium efficient.
5. Service Factor: 1.15.

D. Mounting: Fan wheel, motor, and drives shall be mounted to fan casing with isolators.

2.5 COOLING COILS

A. Capacity Ratings: Comply with ASHRAE 33 and ARI 410.

B. Coil Casing Material: Manufacturer's standard material.

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C. Tube Material: Copper.

D. Tube Header Material: Manufacturer's standard material.

E. Fin Material: Aluminum.

F. Fin and Tube Joints: Mechanical bond.

G. Leak Test: Coils shall be leak tested with air underwater.

H. Refrigerant Coil Capacity Reduction: Circuit coils for interlaced control.

I. Refrigerant Coil Suction and Distributor Header Materials: Seamless copper tube with brazed joints.

2.6 REFRIGERATION SYSTEM

A. Comply with requirements in ASHRAE 15, "Safety Standard for Refrigeration Systems."

B. Refrigerant Charge: Factory charged with refrigerant and filled with oil.

C. Compressors: Reciprocating or scroll compressors with integral vibration isolators, internal overcurrent and overtemperature protection, internal pressure relief, and crankcase heater.

D. Refrigerant: R-410A.

1. Classified as Safety Group A1 according to ASHRAE 34.
2. Provide unit with operating charge of refrigerant.

E. Refrigeration System Specialties:

1. Expansion valve with replaceable thermostatic element.
2. Refrigerant dryer.
3. High-pressure switch.
4. Low-pressure switch.
5. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
6. Brass service valves installed in discharge and liquid lines.

F. Capacity Control:

1. Hot-gas bypass refrigerant control for capacity control with continuous dehumidification on a single compressor.

G. Refrigerant condenser coils:

1. Capacity Ratings: Complying with ASHRAE 33 and ARI 410.
2. Tube Material: Copper.
3. Fin Material: Aluminum.
4. Fin and Tube Joint: Mechanical bond.
5. Leak Test: Coils shall be leak tested with air underwater.

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H. Condenser Fan Assembly:

1. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades.
2. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Motor Enclosure: Totally enclosed non-ventilating (TENV) or totally enclosed air over (TEAO) enclosure.
c. Enclosure Materials: Cast iron.
d. Motor Bearings: Permanently lubricated bearings.
e. Built-in overcurrent and thermal-overload protection.
f. Efficiency: Premium efficient.
g. Service Factor: 1.15. Guards: Steel with corrosion-resistant coating.

I. Safety Controls:

1. Compressor motor and condenser coil fan motor low ambient lockout.
2. Overcurrent protection for compressor motor.

2.7 INDIRECT-FIRED GAS FURNACE HEATING

A. Furnace Assembly:

1. Factory assembled, piped, and wired.
2. Comply with requirements in NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."
3. AGA Approval: Designed and certified by and bearing label of AGA.

B. Burners:

1. Heat-Exchanger Material: Stainless steel with a minimum thermal efficiency of 80 percent.
2. Fuel: Natural gas.
3. Ignition: Electronically controlled electric spark with flame sensor.

C. Heat-Exchanger Drain Pan Material: Stainless steel.

D. Venting: Gravity vented.

E. Venting: Power vent with integral, motorized centrifugal fan interlocked with gas valve.

F. Safety Controls:

1. Gas Control Valve: Electronic modulating.
2. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

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2.8 OUTDOOR-AIR INTAKE HOOD

A. Type: Manufacturer's standard hood or louver.

B. Materials: Match cabinet.

C. Bird Screen: Comply with requirements in ASHRAE 62.1.

D. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.9 FILTERS

A. Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Factory-fabricated, viscous-coated, flat-panel type.
3. Thickness: 2 inches.
4. Minimum Merv: 13, according to ASHRAE 52.2.
5. Media: Interlaced glass fibers sprayed with nonflammable adhesive.

B. Mounting Frames:

1. Panel filters arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or from access plenum.
2. Extended surface filters arranged for flat orientation, removable from access plenum.
3. Galvanized or stainless steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

2.10 ELECTRICAL POWER CONNECTIONS

A. General Electrical Power Connection Requirements: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices shall provide a single-point field power connection to unit.

B. Enclosure: NEMA 250, Type 3R mounted in unit with hinged access door in unit cabinet having a lock and key or padlock and key,

C. Wiring: Numbered and color-coded to match wiring diagram.

D. Wiring Location: Install factory wiring outside an enclosure in a raceway.

E. Power Interface: Field power interface shall be to wire lugs.

F. Factory Wiring: Branch power circuit to each motor and to controls with one of the following disconnecting means:

1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
2. NEMA KS 1, heavy-duty, nonfusible switch.

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3. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

G. Factory-Mounted, Overcurrent-Protection Service: For each motor.

H. Transformer: Factory mounted with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

I. Controls: Factory wire unit-mounted controls where indicated.

J. Receptacle: Factory wire unit-mounted, ground fault interrupt (GFI) duplex receptacle.

K. Control Relays: Auxiliary and adjustable time-delay relays.

2.11 CONTROLS

A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Control Wiring: Factory wire connection for controls' power supply.

C. Control Devices: Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves shall be manufacturer's standard items to accomplish indicated control functions.

D. Remote-Mounted Status Panel:

1. Cooling/Off/Heating Controls: Control operational mode.
2. Damper Position: Indicate position of outdoor-air dampers in terms of percentage of outdoor air.
3. Status Lights:

    a. Filter dirty.
    b. Fan operating.
    c. Cooling operating.
    d. Heating operating.
    e. Smoke alarm.
    f. General alarm.

4. Digital Numeric Display:

    a. Outdoor airflow.
    b. Supply airflow.
    c. Outdoor dry-bulb temperature.
    d. Outdoor dew point temperature.
    e. Space temperature.
    f. Supply temperature.
    g. Space relative humidity.
    h. Space carbon dioxide level.

E. Control Dampers:

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1. Damper Location: Factory installed inside unit for ease of blade axle and bushing service. Arrange dampers located in a mixing box to achieve convergent airflow to minimize stratification.
2. Damper Leakage: Comply with requirements in AMCA 500-D. Leakage shall not exceed 6.5 cfm per sq. ft. at a static-pressure differential of 4.0 inches water column when a torque of 5 inch pounds per sq. ft. is applied to the damper jackshaft.
3. Damper Rating: Rated for close-off pressure equal to the fan shutoff pressure.
4. Damper Label: Bear the AMCA seal for both air leakage and performance.
5. Blade Configuration: Unless otherwise indicated, use parallel blade configuration for two-position control and equipment isolation service and use modulating control when mixing two airstreams. For other applications, use an opposed-blade configuration.
6. Damper Frame Material: Extruded aluminum.
7. Blade Type: Single-thickness metal reinforced with multiple V-grooves
8. Blade Material: Extruded aluminum.
9. Maximum Blade Width: 6 inches.
10. Maximum Blade Length: 48 inches.
11. Blade Seals: Replaceable, continuous perimeter vinyl seals and jambs with stainless-steel compression-type seals.
12. Bearings: Thrust bearings for vertical blade axles.
13. Airflow Measurement:

    a. Monitoring System: Complete and functioning system of airflow monitoring as an integral part of the damper assembly where indicated.
    b. Remote Monitoring Signal: 0-10 volt or 4-20 mA scaled signal.
    c. Accuracy of flow measurement: Within 5 percent of the actual flow rate between the range of the scheduled minimum and maximum airflow. For units with a large range between minimum and maximum airflow, configure the damper sections and flow measurement assembly as necessary to comply with accuracy.
    d. Straightening Device: Integral to the flow measurement assembly if required to achieve the specified accuracy as installed.
    e. flow measuring device: Suitable for operation in untreated and unfiltered outdoor air. If necessary, include temperature and altitude compensation and correction to maintain the accuracy.

F. Damper Operators:

1. Factory-installed electric operator for each damper assembly with one operator for each damper assembly mounted to the damper frame.
2. Operator capable of shutoff against fan pressure and able to operate the damper with sufficient reserve power to achieve smooth modulating action and proper speed of response at the velocity and pressure conditions to which the damper is subjected.
3. Maximum Operating Time: Open or close damper 90 degrees in 60 seconds.
4. Adjustable Stops: For both maximum and minimum positions.
5. Position Indicator and Graduated Scale: Factory installed on each actuator with words "OPEN" and "CLOSED," or similar identification, at travel limits.
6. Spring-return operator to fail-safe; either closed or open as required by application.
7. Operator Type: Direct coupled, designed for minimum 60,000 full-stroke cycles at rated torque.
8. Position feedback Signal: For remote monitoring of damper position.
9. Coupling: V-bolt and V-shaped, toothed cradle.
10. Circuitry: Electronic overload or digital rotation-sensing circuitry.

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G. Refrigeration System Controls:

1. Unit-mounted enthalpy controller shall lock out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb of dry air or outdoor-air temperature is less than 60 deg F.

H. Furnace Controls:

1. Remote sensor for field installation in supply-air duct with sensor adjustment located in control panel to modulate gas furnace burner to maintain space temperature.

I. Damper Controls: Space pressure sensor modulates outdoor- and return-air dampers to maintain a positive pressure in space at a minimum of 0.05 inch wg with respect to outdoor reference.

J. Integral Smoke Alarm: Smoke detector installed in supply and return air.

K. DDC Temperature Control: Standalone control module for link between unit controls and DDC temperature-control system. Control module shall be compatible with control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." Links shall include the following:

1. Start/stop interface relay, and relay to notify DDC temperature-control system alarm condition.
2. Hardware interface or additional sensors for the following:

a. Discharge-air temperature.
b. Refrigeration system operating.
c. Furnace operating.
d. Constant and variable motor loads.
e. Variable-frequency-controller operation.
f. Cooling load.
g. Economizer cycles.
h. Air-distribution static pressure and ventilation-air volumes.

L. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display unit status and alarms.

1. Hardwired Points:

a. Monitoring: On-off status, common trouble alarm.
b. Control: On-off operation, supply temperature set-point adjustment

2. ASHRAE 135 (BACnet) communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the DDC system for HVAC.

2.12 ACCESSORIES

A. Duplex Receptacle: Factory mounted in unit supply-fan section [and refrigeration section], with 20 amp 120 V GFI duplex receptacle and weatherproof cover.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's rigging and installation instructions for unloading units and moving to final locations.

B. Curb Support: Install roof curb on roof structure according to "The NRCA Roofing Manual."

1. Install and secure units on curbs and coordinate roof penetrations and flashing with roof construction.
2. Coordinate size, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
3. Coordinate size, location, and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.

C. Equipment Mounting:

D. Install duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.

E. Comply with requirements for gas-fired furnace installation in NFPA 54, "National Fuel Gas Code."

F. Install separate devices furnished by manufacturer and not factory installed.

G. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

H. Install drain pipes from unit drain pans to sanitary drain.

1. Drain Piping: Drawn-temper copper water tubing complying with ASTM B 88, Type L, with soldered joints.
2. Pipe Size: Same size as condensate drain pan connection.

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3.3 CONNECTIONS

A. Where installing piping adjacent to units, allow space for service and maintenance.

B. Gas Piping Connections:

1. Comply with requirements in Section 221123 "Natural-Gas Piping."
2. Connect gas piping to furnace, full size of gas train inlet, and connect with union, pressure regulator, and shutoff valve with sufficient clearance for burner removal and service.
3. Install AGA-approved flexible connectors.

C. Duct Connections:

1. Comply with requirements in Section 233113 "Metal Ducts."
2. Drawings indicate the general arrangement of ducts.
3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

D. Electrical Connections: Comply with requirements for power wiring, switches, and motor controls in electrical Sections.

1. Install electrical devices furnished by unit manufacturer but not factory mounted.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Inspect units for visible damage to furnace combustion chamber.
3. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:

a. Measure gas pressure at manifold.
b. Measure combustion-air temperature at inlet to combustion chamber.
c. Measure flue-gas temperature at furnace discharge.
d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

4. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

a. High-limit heat exchanger.
b. Alarms.

5. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.

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6. Start refrigeration system when outdoor-air temperature is within normal operating limits and measure and record the following:

    a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
    b. Cooling coil entering-air, dry- and wet-bulb temperatures.
    c. Condenser coil entering-air dry-bulb temperature.
    d. Condenser coil leaving-air dry-bulb temperature.

7. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.

8. Inspect casing insulation for integrity, moisture content, and adhesion.
9. Verify that clearances have been provided for servicing.
10. Verify that controls are connected and operable.
11. Verify that filters are installed.
12. Clean coils and inspect for construction debris.
13. Clean furnace flue and inspect for construction debris.
14. Inspect operation of power vents.
15. Purge gas line.
16. Inspect and adjust vibration isolators.
17. Verify bearing lubrication.
18. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
19. Adjust fan belts to proper alignment and tension.
20. Start unit.
21. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
22. Operate unit for run-in period.
23. Calibrate controls.
24. Adjust and inspect high-temperature limits.
25. Verify operational sequence of controls.
26. Measure and record the following airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.

B. After startup, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace components that do not properly operate and repeat startup procedures as specified above.

D. Prepare written report of the results of startup services.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

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3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 23 74 33

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SECTION 23 81 29

VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes complete VRF HVAC systems including, but not limited to**,** delegated design and the following components to make complete operating systems according to requirements indicated:

1. Indoor, concealed, ceiling-mounted units for ducting.
2. Indoor, exposed, wall-mounted units.
3. Indoor, recessed, ceiling-mounted units.
4. Outdoor, air-source heat recovery units.
5. System controls.
6. System refrigerant and oil.
7. System control cable and raceways.

1.3 DEFINITIONS

A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.

B. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.

C. HRCU: Heat Recovery Control Unit. HRCUs are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and cooling zones. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as branch circuit controller, branch selector box, changeover box, flow selector unit, mode change unit, and other such terms.

D. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

E. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

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F. Three-Pipe System Design: One high pressure refrigerant vapor line, one low pressure refrigerant vapor line, and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One liquid line and refrigerant vapor line connect HRCUs to associated indoor units.

G. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One refrigerant liquid line and refrigerant vapor line connect HRCUs to associated indoor units. HRCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high and low pressure refrigerant between indoor units.

H. VRF: Variable refrigerant flow.

1.4 PREINSTALLATION MEETING

A. Preinstallation Conference: The VRF manufacturer, mechancial contractor and third-party commissioning agent shall conduct a pre-installation meeting at the project site to discuss the installation of VRF systems including the installation of refrigerant piping systems. The manufacturer's representative shall allow a minimum of four (4) hours for this meeting.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for indoor, outdoor units and for HRCUs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.
4. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
5. Include system operating sequence of operation in narrative form for each unique indoor- and outdoor-unit and HRCU control.
6. Include description of control software features.
7. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
8. Include refrigerant type and data sheets showing compliance with requirements indicated.
9. For system design software.
10. Indicate location and type of service access.

B. Shop Drawings: For VRF HVAC systems.

1. Include plans, elevations, sections, and mounting attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

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3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
5. Include diagrams for power, signal, and control wiring.

C. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants.

1. Include a Sample for each unique finish with unit identification, detailed description of application, and cross-referenced floor plans showing locations.

D. Delegated-Design Submittals:

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
2. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.
3. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.
4. Include calculations showing that system travel distance for refrigerant piping and controls cabling are within horizontal and vertical travel distances set by manufacturer. Provide a comparison table for each system installed.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.

a. Retain copies of Installer certificates on-site and make them available on request.

2. For VRF HVAC system manufacturer.
3. For VRF HVAC system provider.

B. Product Certificates: For each type of product.

1. Indoor, concealed, ceiling-mounted units for ducting.
2. Indoor, exposed, wall-mounted units.
3. Indoor, recessed, ceiling-mounted units.
4. Outdoor, air-source heat recovery units.
5. System controls

C. Product Test Reports: Where tests are required, for each product, for tests performed by the manufacturer and witnessed by a qualified testing agency.

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D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranties: For manufacturer's warranties.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters:

a. One set for each unit with replaceable filters.
b. One set for each unit type and unique size of washable filters.

2. Indoor Units: One for each unique size and type installed.
3. Controllers for Indoor Units: One for each unique controller type installed.

1.9 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Nationally recognized manufacturer of VRF HVAC systems and products.
2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of five (5) years within time of bid.
3. VRF HVAC systems and products that have been successfully tested and in use on at least five (5) completed projects.
4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

a. Product research and development.
b. Product and application engineering.
c. Product manufacturing, testing, and quality control.

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d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
e. Owner training.

B. Factory-Authorized Service Representative Qualifications:

1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
2. In-place facility located within 50 miles of Project.
3. Demonstrated past experience with products being installed for period within five (5) consecutive years before time of bid.
4. Demonstrated past experience on five (5) projects of similar complexity, scope, and value.

    a. Each person assigned to Project shall have demonstrated past experience.

5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
6. Service and maintenance staff assigned to support Project during warranty period.
7. Product parts inventory to support ongoing system operation for a period of not less than five (5) years after Substantial Completion.
8. VRF HVAC system manufacturer's backing to take over execution of Work if necessary, to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.

1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
2. Installer certification shall be valid and current for duration of Project.
3. Retain copies of Installer certificates on-site and make available on request.
4. Each person assigned to Project shall have demonstrated past experience.

    a. Demonstrated past experience with products being installed for period within five (5) consecutive years before time of bid.
    b. Demonstrated past experience on five (5) projects of similar complexity, scope, and value.

5. Installers shall have staffing resources of competent, trained, and experienced full-time employees that are assigned to execute work according to schedule.

D. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean and dry place.

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B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.

1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remover coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.

E. Replace installed products damaged during construction.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures.
b. Faulty operation.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.

2. Warranty Period:

a. For Compressor: Ten (10) years from date of Substantial Completion.
b. For Parts, Including Controls: Ten (10) years from date of Substantial Completion.
c. For Labor: Eighteen (18) months after system commissioning.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or equal:

1. Mitsubishi
2. Trane
3. Carrier
4. Daikin AC
5. Samsung
6. Approved Equal

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B. Source Limitations: Obtain products from single source from single manufacturer including, but not limited to, the following:

1. Indoor and outdoor units, including accessories.
2. Controls and software.
3. HRCUs.
4. Refrigerant isolation valves.
5. Specialty refrigerant pipe fittings.

2.2 SYSTEM DESCRIPTION

A. Direct-expansion (DX) VRF HVAC systems with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, HRCUs, piping, controls, and electrical power to make complete operating systems complying with requirements indicated.

1. Two-pipe or three-pipe system design.
2. System operation, air-conditioning and/or heat recovery as indicated on Drawings.
3. Each system with one refrigerant circuit shared by all indoor units connected to system.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. AHRI Compliance: System and equipment performance certified according to AHRI 1230 and products listed in AHRI directory.

D. ASHRAE Compliance:

1. ASHRAE 15: For safety code for mechanical refrigeration.
2. ASHRAE 62.1: For indoor air quality.
3. ASHRAE 135: For control network protocol with remote communication.
4. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: VRF manufacturer’s qualified trained specialist shall design a complete and operational VRF HVAC systems complying with requirements indicated.

1. Provide system refrigerant calculations.

a. Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.
b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.

2. System Refrigerant Piping and Tubing:

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a. Arrangement: Arrange piping to interconnect indoor units, HRCUs, and outdoor units in compliance with manufacturer requirements and requirements indicated.
b. Routing: Conceal piping above ceilings and behind walls to maximum extent possible.
c. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.

3. System Controls:

a. Network arrangement.
b. Network interface with other building systems.
c. Product selection.
d. Sizing.

B. Service Access:

1. Provide and document service access requirements.
2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
4. If less than full and unrestricted access is provided, locate components within an 18-inch reach of the finished assembly.
5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
6. Comply with OSHA regulations.

C. System Design and Installation Requirements:

1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.

D. System Adaptability to Future Changes: Arrange and size system refrigerant piping to accommodate future changes to system without having to resize and replace existing refrigerant piping.

E. Isolation of Equipment: Provide isolation valves to isolate each HRCU, indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.

F. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor unit rated capacity:

1. Not less than 50 percent.
2. Not more than 130 percent.

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G. System Turndown: Stable operation down to 3 percent of outdoor-unit capacity.

H. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in the system.

I. Outdoor Conditions:

1. Suitable for outdoor ambient conditions encountered.

a. Design equipment with supports to withstand wind loads of governing code.
b. Design equipment with supports to withstand snow and ice loads of governing code.

2. Maximum System Operating Outdoor Temperature: Refer to schedule for additional information.
3. Minimum System Operating Outdoor Temperature: Refer to schedule for additional information.

J. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.

1. Indoor: Refer to schedule for sound data.
2. Outdoor: Refer to schedule for sound data.

K. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.

L. Capacities and Characteristics: Refer to schedule for additional information.

2.4 INDOOR, CONCEALED, CEILING-MOUNTED UNITS FOR DUCTING

A. Description: Factory-assembled and tested complete unit with components, piping, wiring, and controls required for mating ductwork, piping, power, and controls field connections.

B. Cabinet:

1. Material: Galvanized or painted steel.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.

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4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:

1. Fan(s):

   a. Direct-drive arrangement.
   b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
   c. Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.
   d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
2. Efficiency: MERV 13.

G. Unit Accessories:

1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor.
2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power and a condensate float switch.

H. Unit Controls:

1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

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a. Unit inlet air temperature.
b. Coil entering refrigerant temperature.
c. Coil leaving refrigerant temperature.

4. Field-Customizable I/O Capability:

a. Analog Inputs: Two for use in customizable control strategies.
b. Digital Inputs: Two for use in customizable control strategies.
c. Digital Outputs: Two for use in customizable control strategies.

5. Features and Functions:

a. Self-diagnostics.
b. Time delay.
c. Auto-restart.
d. External static pressure control.
e. Auto operation mode.
f. Manual operation mode.
g. Filter service notification.
h. Power consumption display.
i. Drain assembly high water level safety shutdown and notification.
j. Run test switch.

6. Communication: Network communication with other indoor and outdoor units.
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Metal, suitable for indoor locations.
2. Field Connection: Single point connection to power unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways.

2.5 INDOOR, EXPOSED, WALL MOUNTED UNITS

A. Description: Factory-assembled and tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.

NOT FOR BIDDING PURPOSES

2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Gravity.

    a. If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.

3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:

1. Fan(s):

    a. Direct-drive arrangement.
    b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
    c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
    d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Front, to accommodate filter replacement without the need for tools.
2. Efficiency: Standard.

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3. Washable Media: Manufacturer's standard filter with antimicrobial treatment.

G. Grille Assembly: Manufacturer's standard discharge grille with field-adjustable air pattern mounted in top or front face of unit cabinet.

H. Unit Accessories:

1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit.
2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power and a condensate float switch.

I. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Field-Customizable I/O Capability:

a. Analog Inputs: Two for use in customizable control strategies.
b. Digital Inputs: Two for use in customizable control strategies.
c. Digital Outputs: Two for use in customizable control strategies.

4. Features and Functions: Self-diagnostics, time delay, auto-restart, auto operation mode filter service notification, power consumption display, drain assembly high water level safety shutdown and notification and run test switch.
5. Communication: Network communication with other indoor units and outdoor units.
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

J. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

2.6 INDOOR, RECESSED, CEILING-MOUNTED UNITS

A. Description: Factory-assembled and tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:

NOT FOR BIDDING PURPOSES

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation**,** complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Internal Tubing: Copper tubing with brazed joints.
6. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:

1. Fan(s):

    a. Direct-drive arrangement.
    b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
    c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
    d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, to accommodate filter replacement without the need for tools.
2. Efficiency: MERV 13.
3. Media:

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a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
b. Washable: Manufacturer's standard filter with antimicrobial treatment.

G. Discharge-Air Grille Assembly: Mounted in bottom of unit cabinet.

1. Discharge Pattern: One-, two-, three-, or four-way throw as indicated on Drawings.

a. Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.
b. Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.

2. Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.
3. Additional Branch Supply Duct Connection: Sheet metal knockout for optional connection to one additional supply branch duct.

H. Return-Air Grille Assembly: Manufacturer's standard grille mounted in bottom of unit cabinet.

I. Unit Accessories:

1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit.
2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power and a condensate float switch.
3. Built in occupancy sensor and surface temperature sensor.

J. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Field-Customizable I/O Capability:

a. Analog Inputs: Two for use in customizable control strategies.
b. Digital Inputs: Two for use in customizable control strategies.
c. Digital Outputs: Two for use in customizable control strategies.

4. Features and Functions: Self-diagnostics, time delay, auto-restart, auto operation mode, filter service notification, power consumption display, drain assembly high water level safety shutdown and notification and run test switch.
5. Communication: Network communication with other indoor units and outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

K. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.

NOT FOR BIDDING PURPOSES

3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

2.7 HEAT RECOVERY CONTROL UNITS (HRCUs)

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.

B. Cabinet:

1. Galvanized-steel construction.
2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

D. Refrigeration Assemblies and Specialties:

1. Specially designed by manufacturer for type of VRF HVAC system being installed, either three or two pipe.
2. Each refrigerant branch circuit shall have refrigerant control valve to control refrigerant flow.
3. Spares: Each heat recovery control unit shall include at least **one** branch circuit port for future use.
4. Each system piping connection upstream of heat recovery unit shall be fitted with an isolation valve to allow for service to any heat recovery control unit in the system without interrupting operation of the system.
5. Each branch circuit connection shall be fitted with an isolation valve and capped service port to allow for service to any individual branch circuit without interrupting operation of the system.

    a. If not available as an integral part of the heat recovery control unit, isolation valves shall be field installed adjacent to the unit pipe connection.

E. Unit Controls:

NOT FOR BIDDING PURPOSES

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: High- and low-pressure sensors.
4. Features and Functions: Self-diagnostics, fuse protection, thermal protection.
5. Communication: Network communication with indoor units and outdoor units.
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

F. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

G. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.8 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units and HRCUs shall include integral controls and connect through an Intelligent Controller, an Intelligent Manager or a BMS interface.
2. Network Communication Protocol: Open control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:

    a. Ethernet connection via RJ-45 connectors and port with transmission at minimum 100 Mbps or higher.
    b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 15 minutes of battery backup operation after a power loss.
    c. Integration shall include control, monitoring, and scheduling.

4. Operator Interface:

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a. Operators shall interface with system and unit controls through the following:

1) Operator interfaces integral to controllers.
2) Web interface through web browser software.
3) Integration with Building Automation System.

b. Users shall be capable of interface with controllers for indoor units' control to extent privileges are enabled. Control features available to users shall include the following:

1) On/off control.
2) Temperature set-point adjustment.

B. VRF HVAC System Operator Software for PC:

1. Software offered by VRF HVAC system manufacturer shall provide system operators with the ability to monitor and control VRF HVAC system(s) from a single dedicated Owner-furnished PC.
2. Software shall provide operators with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.
3. Plan views shall show building plans with location of indoor units and identification superimposed on plans.
4. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
5. Schedules operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Schedules daily, weekly, and annual events.
6. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
7. Supports Multiple Languages: English.
8. Supports Imperial and Metric Temperature Units: Fahrenheit.
9. Displays service notifications and error codes.
10. Monitors and displays up to 3000 item error history and 10000 item operation history for regular reporting and further archiving.
11. Monitors and displays cumulative operating time of indoor units.
12. Able to disable and enable operation of individual controllers for indoor units.
13. Information displayed on individual controllers shall also be available for display.
14. Information displayed for outdoor units, including refrigerant high and low pressures operating refrigerant temperatures, pressures, outdoor electronic expansion valve opening and compressor operation time.

C. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.

a. Include multiple interconnected controllers as required.

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2. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.

    a. Sets schedule for daily, weekly, and annual events.
    b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.

4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.
10. Information displayed for outdoor units, including refrigerant high and low pressures operating refrigerant temperatures, pressures, outdoor electronic expansion valve opening and compressor operation time.
11. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
12. Operator interface through a backlit, high-resolution color display touch panel and web accessible through standard web browser software.

D. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Multiple Language: English.
4. Temperature Units: Fahrenheit.
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
7. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
8. Temperature Display: 1-degree increments.
9. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments.
10. Relative Humidity Display: 1 percent increments.
11. Relative Humidity Set-Point: Adjustable in 1 percent increments.
12. Fan Speed Setting: Select between available options furnished with the unit.
13. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
14. Seven-day programmable operating schedule with up to eight events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
15. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
16. Occupancy detection.
17. Service Notification Display: "Filter".
18. Service Run Tests: Limit use by service personnel to troubleshoot operation.

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19. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
20. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
21. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
22. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

2.9 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 34, Class A1 refrigerant classification.

a. R-410a.

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

C. Refrigerant Isolation Ball Valves:

1. Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.
2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
3. Valve Connections: Flare or sweat depending on size.

2.10 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect factory-assembled equipment.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports for historical record. Submit reports only if requested.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.

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C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.

D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.

E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.

F. Examine walls, floors, roofs, and outdoor locations for suitable conditions where equipment will be installed.

G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION, GENERAL

A. Clearance:

1. Maintain manufacturer's recommended clearances for service and maintenance.
2. Maintain clearances required by governing code.

B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.

1. Loose components shall be installed by manufacturer's service representative or system Installer under supervision of manufacturer's service representative.

3.3 INSTALLATION OF INDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.

C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.

D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replace damaged areas after units are installed.

E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.

F. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch.

G. For wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.

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H. Attachment: Install hardware for proper attachment to supported equipment.

I. Grouting: Place grout under equipment supports and make bearing surface smooth.

3.4 INSTALLATION OF OUTDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Install outdoor units on support structures indicated on the structural drawings.

C. Roof-Mounted Installations: Install outdoor units on equipment supports specified and indicated on the structural division.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping and tubing to permit valve servicing.

F. Install piping and tubing at indicated slopes.

G. Install piping and tubing free of sags.

H. Install fittings for changes in direction and branch connections.

I. Install piping and tubing to allow application of insulation.

J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.

K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

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3.6 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

A. General Requirements for Drain Piping and Tubing:

1. Install a union in piping at each threaded unit connection.
2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:

    a. Details indicated on Drawings.
    b. Manufacturer's requirements.
    c. Governing codes.
    d. In the absence of requirements, comply with requirements of ASHRAE handbooks.

4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

B. Gravity Drains:

1. Slope piping from unit connection toward drain termination at a constant slope of not less than one percent.

C. Pumped Drains:

1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.7 INSTALLATION OF REFRIGERANT PIPING

A. Install refrigerant piping according to ASHRAE 15 and governing codes.

B. Select system components with pressure rating equal to or greater than system operating pressure.

C. Install piping as short and direct as possible, with a minimum number of joints and fittings.

D. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified under the architectural division of the specifications, if valves or equipment requiring maintenance is concealed behind finished surfaces.

E. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping as follows:

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1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps to entrain oil in vertical runs.
4. Liquid lines may be installed level.

F. When brazing, remove or protect components that could be damaged by heat.

G. Before installation, clean piping and fittings to cleanliness level required by VRF HVAC system manufacturer.

H. Joint Construction:

1. Ream ends of tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
3. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

    a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
    b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.8 INSTALLATION OF METAL HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC piping and Equipment".

B. Comply with requirements in Section 230548 "Vibration Controls for HVAC".

C. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

D. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

E. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

F. Install lateral bracing with pipe hangers and supports to prevent swaying.

G. Install building attachments within concrete slabs or attach to structural steel.

1. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

H. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

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I. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

3.9 INSTALLATION OF DUCT, ACCESSORIES, AND AIR OUTLETS

A. Where installing ductwork adjacent to equipment allow space for service and maintenance.

B. Comply with requirements for metal ducts specified in Section 233113 "Metal Ducts."

C. Comply with requirements for air duct accessories specified in Section 233300 "Air Duct Accessories."

D. Comply with requirements for flexible ducts specified in Section 233346 "Flexible Ducts."

E. Comply with requirements for air diffusers specified in Section 233713 "Grilles, Registers and Diffusers."

3.10 INSTALLATION OF SYSTEM CONTROL CABLE

A. Comply with NECA 1.

B. Installation Method:

1. Install cables in raceways except as follows:

   a. Within equipment and associated control enclosures.
   b. In accessible ceiling spaces where open cable installation method may be used.
   c. In gypsum board partitions where cable may be enclosed within wall cavity.

2. Conceal raceway and cables except in unfinished spaces.

C. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable.
5. Cables serving a common system may be grouped in a common raceway. Install control cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.

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9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles or access panels.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals.
15. Do not bend cables in a radius less than 10 times the cable OD.
16. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
17. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

D. Balanced Twisted-Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist balanced twisted-pair cables more than 1/2 inch at the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 30 inches apart.
2. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

F. Separation from EMI Sources: Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded cable from potential EMI sources including electrical power wiring and equipment.

3.11 FIRESTOPPING

A. Comply with requirements in the architectural division of the specifications.

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.12 GROUNDING INSTALLATION

A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control cabling, comply with requirements in the electrical division of the specifications.

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3.13 IDENTIFICATION

A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and Equipment."

B. Identify system electrical and controls components, wiring, cabling, and terminals. Comply with requirements for identification specified in the electrical division of the specifications.

1. Identify each control cable on each end and at each terminal with a number-coded identification tag. Each cable shall have a unique tag.

3.14 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.

1. Field service shall be performed by an employee or a factory-trained and -authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.

a. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative shall not provide assistance without manufacturer's employee supervision.

2. Manufacturer shall provide on-site visits during the course of construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.

a. First Visit: Kick-off meeting.
b. Second Visit: At approximately 15 percent completion of systems.
c. Third Visit: At approximately 30 percent completion of systems.
d. Fourth Visit: At approximately 60 percent completion of systems.
e. Fifth Visit: Final inspection before system startup.

3. Kick-off Meeting:

a. Meeting shall include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.
b. Meeting shall be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.
c. Meeting shall cover the following as a minimum requirement:

1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.
2) Manufacturer's installation requirements specific to systems being installed.
3) Review of all relevant VRF HVAC system submittals, including delegated-design submittals.

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4) Required field activities related installation of VRF HVAC system.
5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.

4. Site Visits: Activities for each site visit shall include the following:

a. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
b. Offer technical support to Installer and related trades as related to VRF system(s) being installed.
c. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
d. Advise and if necessary, assist Installer with updating related refrigerant calculations and system documentation.
e. Issue a report for each visit, documenting the visit.

1) Report to include name and contact information of individual making the visit.
2) Date(s) and time frames while on-site.
3) Names and contact information of people meeting with while on-site.
4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.

5. Final Inspection before Startup:

a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according to manufacturer's requirements and ready for final inspection.
b. All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.
c. Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.
d. Inspection reports for indoor units shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.

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11) Low-voltage reading(s) within an acceptable range.
12) Controller type and model controlling unit.
13) Controller location.
14) Temperature settings and readings within an acceptable range.
15) Humidity settings and readings within an acceptable range.
16) Condensate removal acceptable.
17) Fan settings and readings within an acceptable range.
18) Unit airflow direction within an acceptable range.
19) If applicable, fan external static pressure setting.
20) Filter type and condition acceptable.
21) Noise level within an acceptable range.
22) Refrigerant piping properly connected and insulated.
23) Condensate drain piping properly connected and insulated.
24) If applicable, ductwork properly connected.
25) If applicable, external interlocks properly connected.
26) Remarks.

e. Inspection reports for outdoor units shall include, but not be limited to, the following:

1) Unit designation on Drawings.
2) Manufacturer model number.
3) Serial number.
4) Network address, if applicable.
5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Condensate removal acceptable.
13) Noise level within an acceptable range.
14) Refrigerant piping properly connected and insulated.
15) Condensate drain piping properly connected and insulated.
16) Remarks.

f. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
g. Installer shall correct observed deficiencies found by the inspection.
h. Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.
i. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved and systems are deemed ready for startup.
j. Final report shall indicate the systems inspected are installed according to manufacturer's requirements and are ready for startup.

B. Perform the following tests and inspections with the assistance of manufacturer's service representative:

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1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Refrigerant Tubing Positive Pressure Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.5 times VRF HVAC system operating pressure, but not less than 535 psig, using dry nitrogen.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.
    g. Name of person ending test, company name, phone number, and e-mail address.
    h. Date and time at end of test.
    i. Test pressure at end of test.
    j. Outdoor temperature at end of test.
    k. Remarks:

5. Submit test reports for Project record.

D. Refrigerant Tubing Evacuation Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour with no change.
4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.

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e. Test pressure at start of test.
f. Outdoor temperature at start of test.
g. Name of person ending test, company name, phone number, and e-mail address.
h. Date and time at end of test.
i. Test pressure at end of test.
j. Outdoor temperature at end of test.
k. Remarks:

5. Submit test reports for Project record.
6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.

E. System Refrigerant Charge:

1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
3. System refrigerant charging shall be witnessed by system manufacturer's representative.
4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.

F. Products will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.15 STARTUP SERVICE

A. Engage a VRF HVAC system manufacturer's service representative to perform system startup service.

1. Service representative shall be an employee or a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
2. Complete startup service of each separate system.
3. Complete system startup service according to manufacturer's written instructions.

B. Startup checks shall include, but not be limited to, the following:

1. Check control communications of equipment and each operating component in system(s).
2. Check each indoor unit's response to demand for cooling and heating.
3. Check each indoor unit's response to changes in airflow settings.
4. Check each indoor unit, HRCU, and outdoor unit for proper condensate removal.
5. Check sound levels of each indoor and outdoor unit.

C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.

1. Installer shall correct deficiencies found during startup service for reverification.

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D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.

    a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. Invite Commissioning Agent to witness startup service procedures.
2. Provide written notice not less than 10 business days before start of startup service.

3.16 ADJUSTING

A. Adjust equipment and components to function smoothly and lubricate as recommended by manufacturer.

B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.

C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.

D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.17 PROTECTION

A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.

B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.

C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.

D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

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3.18 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of system Installer who are manufacturer's authorized service representative. Include four service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.19 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.20 DEMONSTRATION

A. Engage a VRF HVAC system manufacturer's employed training instructor or [factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.

B. Instructor:

1. Instructor shall be factory trained and certified by VRF HVAC system manufacturer with current training on the system(s), equipment, and controls that are installed.
2. Instructor's credentials shall be submitted for review by Commissioning Agent before scheduling training.
3. Instructor’s sole job responsibility shall be Owner training.
4. Instructor’s shall have not less than three years of training experience with VRF HVAC system manufacturer and past training experience on at least three projects of comparable size and complexity.

C. Schedule and Duration:

1. Schedule training with Owner at least 20 business days before first training session.
2. Training shall occur before Owner occupancy.
3. Training shall be held at mutually agreed date and time during normal business hours.
4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for one-hour lunch period and 15-minute break after every two hours of training.
5. Perform not less than twenty-four (24) total hours of training.

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D. Location: Owner shall provide a suitable on-site location to host classroom training.

E. Training Attendees: Assume **three** people.

F. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.

G. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training.

H. Training Materials: Provide training materials in electronic format to each attendee.

1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.

I. Acceptance: Obtain Commissioning Agent written acceptance that training is complete and requirements indicated have been satisfied.

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SECTION 23 82 39.13

CABINET UNIT HEATERS

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section includes cabinet unit heaters with centrifugal fans and electric-resistance heating coils.

1.4 DEFINITIONS

A. DDC: Direct digital control.

B. PTFE: Polytetrafluoroethylene plastic.

C. TFE: Tetrafluoroethylene plastic.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include location and size of each field connection.
4. Include details of anchorages and attachments to structure and to supported equipment.
5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.

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6. Indicate location and arrangement of piping valves and specialties.
7. Indicate location and arrangement of integral controls.
8. Wiring Diagrams: Power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

D. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

E. Samples for Verification: Finish colors for each type of cabinet unit heater indicated with factory-applied color finishes.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cabinet unit heaters to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Cabinet Unit-Heater Filters: Furnish **one** spare filter for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Berko; Marley Engineered Products.
2. Chromalox, Inc.
3. Markel Products; TPI Corporation.
4. Marley Engineered Products.
5. QMark; Marley Engineered Products.
6. Approved Equal.

2.2 DESCRIPTION

A. Factory-assembled and -tested unit complying with AHRI 440.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 2021.

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2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.4 COIL SECTION INSULATION

A. Insulation Materials: ASTM C 1071; surfaces exposed to airstream shall have erosion-resistant coating to prevent erosion of glass fibers.

1. Thickness: 1/2 inch.
2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Insulation Materials: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.

1. Thickness: 1 inch.
2. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.5 CABINETS

A. Material: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.

1. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch thick galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
2. operated.
3. Base: Minimum 0.0528-inch-thick steel, finished to match cabinet, 4 inches high with leveling bolts.

2.6 FILTERS

A. Minimum Arrestance: According to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

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1. Pleated: 90 percent arrestance, MERV 8.

2.7 COILS

A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

2.8 CONTROLS

A. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

B. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

C. Basic Unit Controls:

1. Control voltage transformer.
2. Unit mounted thermostat with the following features:

    a. Heat-off switch.
    b. Fan on-auto switch.
    c. Manual fan-speed switch.
    d. Adjustable deadband.
    e. Concealed set point.
    f. Concealed indication.
    g. Deg F indication.

3. Data entry and access port.

    a. Input data includes room temperature and occupied and unoccupied periods.
    b. Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.

D. DDC Terminal Controller:

1. Scheduled Operation: Occupied and unoccupied periods
2. Unit Supply-Air Fan Operations:

    a. Occupied Periods: Fan runs continuously.

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b. Unoccupied Periods: Fan cycles to maintain setback room temperature.

3. Heating-Coil Operations:

a. Occupied Periods: Energize electric-resistance coil to provide heating if room temperature falls below thermostat set point.
b. Unoccupied Periods: Start fan and energize electric-resistance coil if room temperature falls below setback temperature.

4. Controllers shall have volatile-memory backup.

E. Interface with DDC System for HVAC Requirements:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at central workstation.
3. Interface shall be BAC-net compatible for central DDC system for HVAC workstation and include the following functions:

a. Adjust set points.
b. Cabinet unit-heater start, stop, and operating status.
c. Data inquiry, including supply-air and room-air temperature.
d. Occupied and unoccupied schedules.

F. Electrical Connection: Factory-wired motors and controls for a single field connection.

2.9 CAPACITIES AND CHARACTERISTICS

A. Refer to schedule on the drawing for capacities and characteristics.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly, seal and weatherproof. Joint-sealant materials and applications as specified in the architectural division.

B. Install cabinet unit heaters to comply with NFPA 90A.

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C. Install new filters in each unit within one week of Substantial Completion.

3.3 CONNECTIONS

A. Ground equipment according to the electrical division of the specifications.

B. Connect wiring according to the electrical division of the specifications.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

END OF SECTION 23 82 39.13

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SECTION 23 82 39.19

WALL AND CEILING UNIT HEATERS

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

A. Section includes wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details of anchorages and attachments to structure and to supported equipment.
4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
5. Wiring Diagrams: Power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

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PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Berko; Marley Engineered Products.
2. Chromalox, Inc.
3. Markel Products; TPI Corporation.
4. Marley Engineered Products.
5. QMark; Marley Engineered Products.
6. Approved Equal.

2.2 DESCRIPTION

A. Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 CABINET

A. Front Panel: Stamped-steel louver with removable panels fastened with tamperproof fasteners.

B. Finish: Baked enamel over baked-on primer with manufacturer's custom color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

2.4 COIL

A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection. Provide integral circuit breaker for overcurrent protection.

2.5 FAN AND MOTOR

A. Fan: Aluminum propeller directly connected to motor.

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B. Motor: Permanently lubricated, multispeed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.6 CONTROLS

A. Controls: Unit-mounted thermostat. Low-voltage relay with transformer kit.

B. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.

2.7 CAPACITIES AND CHARACTERISTICS

A. Refer to schedules on the drawings for capacities and characteristics.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive wall and ceiling unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall and ceiling unit heaters to comply with NFPA 90A.

B. Install wall heaters and ceiling unit heaters level and plumb.

C. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with drawings and room details before installation.

D. Ground equipment according to the electrical division of the specifications.

E. Connect wiring according to the electrical division of the specifications.

END OF SECTION 23 82 39.19

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SECTION 26 00 00

GENERAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 COMMISSIONING

A. Each contractor and vendor shall be part of a total building and system commissioning effort as conducted by the Commissioning Agent. Each contractor shall provide a technician and tools required to assist and facilitate the commissioning agent, as outlined by the commissioning plan. Full scope of work and all related responsibilities will be defined in Commissioning documentation.

1.2 RELATED DOCUMENTS:

A. Division 01 Specifications, General and Supplemental Requirements apply to this section with additions and modifications specified herein.

B. This Section shall apply to all Divisions 26, 27, and 28 Sections of these specifications as hereinafter written.

C. Instructions to Bidders, Bidding Forms, Forms of Agreement between Owner and Contractor, Contract Award Date, Starting and Completion Dates, Conditions of the Contract, Insurance Requirements, and other Owner Requirements shall be furnished separately by the Owner, General Contractor or Construction Manager. These documents, as well as any addenda issued, shall form a part of these Specifications, and this Contractor shall consult them in detail for instructions pertaining to their work.

D. Each contractor and sub-contractor shall be provided with all drawings and specification sections issued as part of the overall bid package, as well as all subsequent Addenda, Architects Supplemental Instructions (ASI), Bulletins or other project contract documents. All contractors and sub-contractors are to receive, review, and coordinate all of their work as shown or referenced on the other trade documents. All work shown or referenced on the other trade documents shall be included as part of the overall project scope. It is each contractor or sub-contractor's responsibility to confirm, prior to submitting their bid, that they have received all contract documents and supplemental information.

1.3 SCOPE OF WORK:

A. These specifications, accompanying drawings and all other contract documents are intended to cover the furnishing of all labor, material, equipment, and superintendence of the Electrical System for this project. They are also intended to cover performing all miscellaneous operations including excavations and backfilling, cutting, channeling, chasing, and patching necessary for the installation of the Electrical systems, as shown on the drawings, as hereinafter

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specified, as directed by the Engineer or as may be required for a complete and fully functional electrical installation.

B. It is the intent and purpose of these specifications, accompanying drawings and all other contract documents to cover and include each item, all materials, equipment, apparatus, and labor necessary to properly install, equip, adjust, and put into perfect operation the respective portions of the installations specified and to so interconnect the various items or sections of the work as to form a complete and properly operating whole.

C. Drawings and specifications have been prepared with best knowledge of conditions available at the time of design and are intended to be complementary. What is called for by one shall be as binding as if called for by both. Where conflicts occur between drawings and specifications, or between the Electrical documents and the documents of other disciplines, the situation shall be brought to the attention of the Design Professional before the work in question is installed. In case of conflict between provisions of the Specifications or between the drawings and the specifications, the more stringent requirement shall govern. Where a requirement is applied to a specific product, condition, system or Specification Section which conflicts with a more general requirement elsewhere, the specific shall supersede the general. If any obscurities or discrepancies exist, they shall be brought to the attention of the Design Professional before bids are submitted. If they are not discovered before bids are submitted, the Design Professional shall be notified and shall render a decision. This decision shall be final.

D. Any equipment, apparatus, machinery, material and small items not mentioned in detail, and labor not hereinafter specifically mentioned, which may be found necessary to complete or perfect any portion of the installation in a substantial manner, and in compliance with the requirements stated, implied or intended in these specifications shall be furnished without extra cost. This shall include all materials, devices or methods peculiar to the machinery, equipment, apparatus, or systems furnished and installed as part of the ELECTRICAL work, and shall include major components if so required.

E. The general arrangement of conduit, wiring and equipment shall be as identified on the contract drawings. Carefully examine all contract drawings and be responsible for the proper fitting of materials and equipment in each location as indicated. Inasmuch as the drawings are generally diagrammatic, due to their small scale, it is not possible to indicate all offsets, fittings and accessories, as may be required in the final installation. Carefully investigate the site, structural, and finish conditions affecting their work and arrange such work accordingly, providing such fittings and accessories as may be required to meet such conditions, at no additional cost to the Owner. The right to make any reasonable change in location of apparatus, equipment, outlets or routing of conduit and wiring, up to the time of roughing-in, is reserved by the Design Professional without involving any additional expense to the Owner.

F. Should a bidder find discrepancies in or omissions from the drawings or specifications they shall notify the Design Professional before submitting their bid proposal. The Design Professional shall then send written instructions, via Addendum, to all known bidders. Oral instructions shall not be binding to either the Design Professional or the Owner.

G. In the case of discrepancies or conflicts between the Drawings and Specifications, typically the Drawings will take precedence in the case of quantitative issues, while the Specifications will take precedence for qualitative issues; or as specified in other Divisions; however, when the scale and date of the Drawings are the same, or when a discrepancy exists within the

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Documents and specific written direction cannot be obtained from the Design Professional, Bidders shall include the most stringent requirements. Obtain written clarification from the Engineer prior to installation.

H. Any such items not brought to the attention of the Design Professional prior to submission of the bids shall be subject to the interpretation of the Design Professional. All such interpretations shall be accepted by the Contractor and shall be incorporated into the construction in a timely manner, at no additional cost to the contract.

I. These Specifications are arranged in accordance with the MasterFormat 2016, 35 Division format. The Specification is to be read as a whole. Items or work called for on one paragraph or Section, shall be applicable to the entire work, unless specifically indicated otherwise. Specific contract scopes shall be as determined by the General Contractor or Construction Manager.

1.4 DEFINITIONS:

A. The following are definitions of words found in the various Sections of Divisions 26, 27 and 28 and on the associated Electrical drawings:

1. "Concealed" shall indicate hidden from normal sight in furred spaces, shafts, ceiling spaces, walls and partitions.
2. "Exposed" shall indicate work normally visible, including work in Mechanical or Electrical equipment rooms, tunnels, and similar spaces.
3. "Provide" (and tenses of "provide") – shall indicate "supply and install, complete in all respects, for a complete and fully functional installation."
4. "Install" (and tenses of "install") – shall indicate "secure in position, make all final connections complete, test, verify and certify for a complete and fully functional installation."
5. "Furnish" (and tenses of "furnish") – shall indicate "supply only, complete with all required accessories, mounting hardware, etc., for installation by others, or as spare "attic" stock for the Owner's future use."
6. "Engineer" shall indicate person, firm or Corporation representing the Owner, and identified as such in the Contract Documents. The terms "Engineer" and "Architect" may be used interchangeably throughout the documents.
7. "Authority Having Jurisdiction (AHJ)" shall indicate the organization, office, or individual responsible for enforcing the requirements of the applicable codes or standards in the location where the project is to be constructed.
8. "BAS" shall indicate Building Automation System and which shall also refer to by equivalent to references to "ATC" – Automatic Temperature Controls, "BMS" – Building Management System or "FMS" – Facility Management System. Any and all of these terms and acronyms may be used interchangeably to refer to the same functional system, specified under Divisions 21 - 25.

1.5 LAWS, REGULATIONS AND CODES:

A. Perform all work in strict compliance with all laws, regulations, and/or codes applying, including all Federal, State and local codes and any other authority having jurisdiction.

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Wherever drawings or specifications conflict with such regulations they shall be made to conform, and approval of the Design Professional obtained on such changes as may be involved.

1.6 QUALITY ASSURANCE:

A. Perform all work hereunder in strict accordance with all requirements of the Authorities Having Jurisdiction over this work. The editions currently in force within the local jurisdiction of the following codes, regulations, standards, and specifications, shall be strictly followed throughout prosecution of the work:

1. American National Standards Institute (ANSI)/National Institute of Standards and Technology (NIST)
2. National Fire Protection Association (NFPA)
3. NFPA-72 – National Fire Alarm Code 2019
4. NFPA-70 – National Electrical Code (NEC) 2020
5. NFPA 70E – Standard for Electrical Safety in the Workplace
6. NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems 2018
7. NFPA-101 – Life Safety Code 2021
8. National Electrical Manufacturers Association (NEMA)
9. Institute of Electrical & Electronic Engineers (IEEE)
10. International Electrical Testing Association (NETA) Acceptance Testing Specifications
11. Underwriters' Laboratories, Inc. (U.L.)
12. Reflector and Lamp Manufacturers' Institute (RLM)
13. International Building Code (IBC) 2018
14. International Energy Conservation Code (IECC) 2018
15. International Mechanical Code (IMC) 2018
16. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)
17. American Society for Testing and Materials (ASTM)
18. Safety Code for Elevators and Escalators (AMSE/ANSI A17.1)
19. Occupational Safety and Health Administration (OSHA)
20. ANSI/NECA 1-2015, Standard Practices for Good Workmanship in Electrical Contracting
21. IEEE C2, National Electrical Safety Code (NESC)
22. Facility Guidelines Institute (FGI) Guidelines for Design and Construction
23. The Joint Commission
24. State of Delaware Department of Health
25. The Town of Smyrna
26. Verizon
27. Comcast Cable Television/Xfinity
28. Local Building and Electrical codes, or amendments to the above listed Codes
29. All other applicable Federal, State or Local Codes, Regulations and Legislation
30. Delaware Home of the Chronically Ill Design Standards

B. All packaged equipment shall be independently Third Party labeled as a system for its intended use by a Nationally Recognized Testing Laboratory (NRTL) in accordance with the OSHA

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Federal Regulations 29CFR1910.303 and .399, as well as National Electric Code (NEC, NFPA-70), Article 90.7.

1.7 PERMITS, FEES, AND CERTIFICATES OF APPROVAL:

A. Unless stated otherwise in General Conditions or Division 01, obtain and pay for all permits, fees, and licenses required, including those of utilities and Agencies. Provide copies to Design Professional in the quantity requested.

B. Include Power Company and other utility connection charges and fees in the Bid. "Fees" shall include connection charges construction costs, and other such charges by utility companies or service providers. Ascertain such charges during bidding period and include bid price.

C. As a prerequisite to final acceptance, supply to the Design Professional a Certificate of Inspection from the local Electrical Inspector. Certificate shall cover rough wiring, fixtures, and equipment. All costs for the necessary inspections shall be included in the bid.

1.8 REQUESTS FOR INFORMATION (RFI)

A. Contractor shall be responsible for submitting Requests for Information (RFI)s when discrepancies arise, logical discrepancies are found on the contract documents, or clarification is necessary. All RFIs must be clearly written and submitted including a suggested solution. All RFIs regarding changes to the intent indicated on plans must be accompanied by sketches, explanation, site pictures, and all other instruments necessary, to clearly convey the issue at hand and the suggested solution. The RFI process may only be utilized for legitimate purposes. RFIs may not be utilized to submit deviation or substitution requests, nor requesting confirmation of scope for items clearly defined on the contract documents, nor related to clarifications that should be resolved through the Contractor's coordination efforts. RFIs that do not comply will be summarily rejected and any delays caused as a result are the responsibility of the Contractor. In cases where the Contractor does not submit an RFI to clarify an issue and incorrectly proceeds, all work required to resolve such issues to be in compliance with the intent of the contract documents, as determined by the Engineer, shall be the Contractor's responsibility and at no additional cost to the project.

B. Carefully examine all architectural and structural drawings for the building as well as all of the drawings for electrical, IT/AV/Security, mechanical, plumbing, fire protection and all other disciplines and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit, equipment or structure. Refer to the coordination drawing requirements. Proper judgment shall be exercised to secure best possible headroom, ceiling heights, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment and conduit, and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may be incurred shall be obtained from the Design Professional and the Owner before proceeding.

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1.9 RECORD DRAWINGS:

A. Throughout the construction keep an accurate, up-to-date record of all deviations of the work between that as shown on the drawings and that which is actually installed.

B. Obtain a complete set of prints of the Electrical drawings and note changes thereon. The design professional will provide the CAD files or Revit model for the contractor's use. Make a complete record in a neat and accurate manner, of all changes and revisions to original design which exist in completed work. As-Built markups shall be updated on a daily basis.

C. Submit As-Built documents in electronic BIM file format. The project design files will be provided to the Contractor by the Design Professional following proper execution of the Document Release and Indemnity Form as provided by the Design Professional. The electronic files returned by the Contractor shall be fully compatible with the native (Revit *.rvt file format) software used by the Design Professional to create the original documents. In addition, submit a complete set of drawings in PDF format.

D. Room names and numbers shall be brought up to date to reflect actual project room signage and designations, which may be different from room indications shown on the contract drawings.

E. The cost of preparing these record drawings shall be borne by the Contractor. When all revisions showing the work as finally installed are made, the prints and BIM files shall be submitted for review and approval by the Design Professional.

F. Record drawings shall be delivered to Owner within 30 days of project Substantial Completion.

1.10 OPERATION AND MAINTENANCE MANUALS:

A. Provide for the Owner's Use one (1) hard copy printed version and one (1) electronic copies in PDF format of a facility Operation and Maintenance Manual.

1. Each hard copy Manual shall be bound in an extra heavy duty three-ring loose-leaf binder with the following title lettered on the front "Record and Information Manual (insert name of project)". No sheets larger than 8-1/2" x 11" shall be used, except sheets that may be neatly folded to 8-1/2" x 11" and used as a pullout.
2. Each electronic format Manual shall be provided as a single .PDF file, fully bookmarked and indexed, containing all Owner's Manual data and project drawings.

B. Provide the following information in each Manual:

1. Cuts of all equipment with manufacturer's technical specifications. Material shall be manufacturer's brochures, catalog cuts, parts lists, wiring diagrams, etc. Also include approved shop drawings.
2. Operation, Maintenance and Servicing Procedures. Include frequency of inspection, cleaning and adjusting and other attention as may be required in accordance with manufacturer's instructions.

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3. Printed copies of machine generated Panelboard Directories. Also include each Panelboard Directory in editable electronic format files.
4. Copy of project Warranty.
5. Contact name, telephone number and email address for obtaining replacement parts and service for all equipment.
6. Copy of all individual equipment warranties.
7. Copies of all required Test Reports.
8. USB drive with all Special Systems drawings in both PDF and editable format.
9. Printed copy of Short Circuit, Coordination and Arc Flash Study.
10. Electronic copy of the Short Circuit, Coordination and Arc Flash Study in native software data format, to allow the Study to be updated in the future.
11. Electronic copy of all Owners Instruction and Training Sessions.

C. Furnish qualified personnel to instruct the Owner's personnel in the maintenance and operation of all equipment and systems. Instructing personnel shall remain on the job continuously during working hours until such instruction is complete, but not less than 16 hours.

D. A video recording in digital format of the operator training session shall be made during this training period and the digital video submitted to the Owner with the Operation and Maintenance Manuals.

1.11 WARRANTY:

A. The material and workmanship of all parts of the electrical installations specified herein and shown on the drawings shall be warranted unconditionally for a period of two (2) years from date of Project Substantial Completion against mechanical and electrical defects arising from faulty materials or workmanship. Either replacement or repairs shall be made promptly on any defective materials or workmanship without charge for materials, equipment or labor during that period.

B. Manufacturer’s warranties on equipment provided under this contract shall be included in the operating and maintenance manuals.

C. See specification section regarding restrictions on Early Use of Electrical Equipment.

1.12 CORRECTION OF WORK AFTER FINAL PAYMENT AND WARRANTY:

A. This article is supplementary to Warranty Provisions of Division 01 and General Conditions.

B. Final payment shall not relieve the Contractor of responsibility for correction of faulty equipment, materials and workmanship and, unless otherwise specified, they shall remedy any defects due thereto and pay for damage to other work resulting therefrom, which shall appear within the warranty period specified above.

C. Include warranties by the respective equipment manufacturers which shall be subject to the terms and time limits defined under these Divisions of Specifications.

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D. Warranties furnished by Sub-Contractor and/or equipment manufacturers shall be counter-signed by the related Prime Contractor for joint and/or individual responsibility for subject item.

E. Manufacturers' equipment guarantees or warranties extending beyond the warranty period described herein shall be transferred to the Owner along with the Contractor's warranties.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT:

A. All installed materials and equipment shall be new and the best of their kind and shall conform to the grade, quality and standards specified herein.

B. Unless otherwise specifically stated, all materials and equipment offered under these specifications shall be limited to products regularly produced and recommended by the manufacturer for the service intended. This material and equipment shall have capacities and ratings sufficient to amply meet the requirements of the project. The capacities and ratings shall be in accord with engineering data or other comprehensive literature made available to the public by the manufacturer and in effect at the time of opening of bids.

C. Equipment shall be installed in accordance with manufacturer's instructions for type and quality of each piece of equipment used. These instructions shall be obtained from the manufacturer and shall be considered part of these specifications. Type, capacity and application of equipment shall be guaranteed suitable to operate satisfactorily. No experimental material or equipment shall be permitted.

2.2 EXCAVATION, BACKFILL AND GRADING:

A. Provide all excavation, bedding, backfill and final grading work required for the installation of the electrical systems under this project.

B. All excavation shall be unclassified, including the excavation and removal of all soil, shale, rock, boulders, existing foundations, fill and every kind of sub-surface condition encountered in the excavation area. Perform all excavation of whatever substance encountered, to the depths indicated on the drawings or as required to route electrical utilities to avoid conflicts with new and existing underground utilities. No extra or additional compensation for excavation will be paid under this Contract.] [It is assumed that all excavation under this Contract will be soil excavation. Perform all excavation of whatever substance encountered, to the depths indicated on the drawings or as required to route electrical utilities to avoid conflicts with new and existing underground utilities. In event that rock is encountered, the Contractor shall be compensated for rock excavation in accordance with the unit prices or soil and rock excavation. Include unit prices for soil and rock excavation and the unit prices for soil excavation to be omitted in the Bid. Rock excavation shall consist of solid rock or boulders over two cubic yards in volume or other material which can only be removed by line drilling or chipping by power equipment; blasting will not be permitted. In event rock is encountered notify the Design Professional of its existence in the areas not to be excavated and accurate measurements of the extent of the rock actually removed shall be made and submitted to the Design Professional.

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C. All excavation shall be made by open cut. The banks of the trenches shall be kept as nearly vertical as safe and practicable. Where required provide sheeting, shoring and bracing.

D. All excavation material not required or suitable for fill or backfill shall be removed from the project site and shall be properly and legally disposed of in strict accordance with all applicable laws and regulations.

E. To protect persons from injury, and to avoid property damage, provide adequate barricades; construction, danger and warning signs; warning lights; lanterns and guards. All such protections shall be placed and maintained throughout the progress of the construction work and until it is safe for traffic use. Rules and regulations of the Owner and local authorities respecting safety provisions shall be strictly observed.

F. Trenches shall be of sufficient width to provide a free working space of not less than 24 in. on each side of the conduit, whichever is greater. Trenches shall also be wide enough to thoroughly compact the backfilling around the conduit or ductbank and to secure a firm bed.

G. In earth excavation, the trench shall be carried to the bottom of the conduit. Where rock excavation is encountered, the trench shall be carried to a point 6 in. below the construction. No construction shall be bedded directly upon rock but shall be cushioned by a 6 in. layer of selected crushed stone or gravel.

H. Where material is removed below the grade of the bottom of a structure it shall be replaced with concrete of the same quality as the concrete in the structure. Where material is removed below the grade of a trench it shall be replaced with a lean concrete mix. Make no excavation to depth below a line of slope one ft. rise on 2 ft. length from such excavation to bottom of footing on other construction.

I. Maintain banks at all times by means of shoring and bracing to avoid cave-in and make good any damage done to property or work of others due to failure to properly shore any excavation. Shoring shall be removed after installation and testing of lines have been approved. Material for shoring shall be placed in accordance with the regulations of the Occupational Safety and Health Agency.

J. All excavations shall be left open until inspected and approved by the Design Professional or Inspection Authority. After the work has been installed and inspected, the excavation shall be backfilled with best carefully selected material free from stones, large pebbles, hard lumps or frozen earth. All backfill shall be made in 8 in. layers. The first 2 layers shall be of fine earth, hand tamped. The remainder of the fill over new construction to the surface shall ordinary approved excavated material placed in 8 in. layers and thoroughly compacted to not less than 90% of maximum Modified Density as determined by ASTM D1557-70. No water soaking will be permitted. All excess materials shall be disposed of as directed.

K. Where excavation is required under existing walkways and roadways, surface shall be restored with new materials equivalent to the material originally used. Whole cement pavement blocks shall be removed and replaced; removal and repair of partial blocks is not permitted.

L. Excavation through unpaved areas shall be seeded and straw covered.

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M. Provide poly plastic warning tape, 6" wide, with foil backing, imprinted "CAUTION BURIED ELECTRIC LINE BELOW" continuously along full length of all trenches above all conduits and ductbanks. Tape shall be printed with black ink on APWA (American Public Works Association) and local electric utility approved color. Tape shall be minimum 12" below grade. Tape shall be Seton or approved equal.

2.3 PUMPING/DEWATERING:

A. Provide pumping equipment to pump all water to prevent it from collecting in trenches, basement areas, and any other excavations necessary to carry out contract requirements. Prepare run-off trenches as required to pump water into and use surplus earth to form dam at top of excavation to run back surface water.

2.4 CHASES AND OPENINGS:

A. Provide information to the appropriate trades regarding size and location of all openings and chases for the installation of this Electrical Work.

2.5 CUTTING AND PATCHING:

A. Provide all cutting, channeling, chasing and patching required for work performed under this Contract.

B. No holes may be cut or drilled in structural members without prior approval of Owner's Representative and Design Professional. Cutting shall be done by mechanics skilled in their respective trades.

C. No cutting that may impair the strength of the building construction shall be done. No holes may be drilled in or attachments welded to the beams or other structural members without prior approval from the Owner's Representative and Design Professional. All work shall be done by mechanics skilled in their trade.

D. Provide sleeves for conduits passing through poured concrete decks, footings, walls, etc. Cut all openings for conduits passing through precast concrete or existing concrete masonry. Such holes shall be cut with core drill or similar equipment. They shall not be cut with hammer or chisel, or with any power tool depending on impact for its cutting power.

E. All patching shall be done in a manner to match appearances and quality of existing surfaces and shall be performed by mechanics skilled in their trade.

2.6 CONCRETE:

A. Provide concrete housekeeping pads (interior) or foundations (exterior) for all generators, switchboards, transformers, motor control centers, and other floor or at grade mounted electrical equipment.

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B. Concrete shall have a compressive strength of 3,000 psi minimum at twenty-eight days. Placing of reinforcing steel and concrete shall be done according to the recommendations of the American Concrete Institute and Concrete Reinforcing Steel Institute, and all materials shall conform to American Society for Testing Materials Specifications, applicable to this work. Equipment pads shall be properly dowelled in with floor construction and shall have sloped bevels on all horizontal and vertical edges. Concrete shall be as specified under Division 03 - Concrete. Provide to the appropriate trade all information required to properly complete concrete work.

C. Form work shall be of sufficient strength to maintain desired shape during pouring of concrete and tight enough to prevent leakage of the grout through joints.

D. Submit shop drawings for approval showing dimensions, reinforcing and dowelling.

E. Equipment Pads and Foundations

1. Unless otherwise indicated or required, concrete housekeeping pads or foundations shall extend a minimum of 4-inches beyond the equipment base in all directions and shall be a minimum of 6 inches above floor or grade.
2. The top edges shall be chamfered.
3. The surface finish shall be the same as the adjacent surrounding floor.
4. Interior concrete housekeeping pads shall be securely anchored to the floor slab with steel dowels.
5. Where indoor equipment weight is such that the floor slab will support the equipment and no housekeeping pad is indicated on the drawings, bolt the equipment directly to the floor slab.
6. Exterior equipment pads shall be turned down on all sides to a minimum of 6” below the frost line as defined by the building code.

F. Furnish and set, with proper templates, at the time of pouring concrete, all anchor bolts and inserts required for the proper attachment of equipment to the concrete foundations. Anchor bolts shall be of the size and quantity required by the equipment manufacturer and shall be in accordance with the requirements detailed on the drawings and/or specified for the equipment.

G. Drop-in wedge anchor bolts or self-drilling anchors may be used in place of hook bolts for equipment other than light poles. Minimum embedment in concrete of wedge anchor bolts shall be in accordance with manufacturer's instructions. Wedge anchor bolts shall be manufacturer by Phillips Drill Co. or USM Corp. Self-drilling anchors shall be manufactured by Phillips Drill Co.

H. After equipment is set in place and bolted down, any space between equipment base and floor slab or foundation shall be completely filled with non-shrink grout equal to Master Builders Co., Ltd. Embeco 153 grout.

2.7 TESTING AND ENERGIZING:

A. Provide all labor, materials, instruments, fuel and power required to perform all necessary tests on all electrical systems (feeders, branch circuits, power distribution systems, electrical equipment, etc.). All tests shall be performed in accordance with industry standards and

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recommendations of the equipment manufacturer, and to the satisfaction of the Design Professional. All defective materials and/or workmanship discovered as a result of these tests, shall be removed and replaced at the Contractor's expense and the test shall be repeated until all associated work passes the test.

B. Test the entire electrical system in accordance with all applicable requirements of the latest edition of the InterNational Electrical Testing Association (NETA) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems (ANSI/NETA ATS) and ANSI/NETA Standard for Electrical Commissioning Specifications for Electrical Power Equipment and Systems.

C. On completion of the installation and wiring covered by this Specification the installation shall be thoroughly proved free from grounds and short circuits and left ready for operation. Necessary adjustments to all equipment shall be made in cooperation with the equipment manufacturer.

D. Balance all three-phase panels to within a maximum of ten percent (10%) imbalance. Submit a report of current readings obtained for each panel after balancing has been completed.

E. Test all special systems or equipment for proper operation as described in the respective specification sections.

F. Test all motors for proper rotation. Indicate that rotation by affixing an adhesive arrow, equal to Brady Label Co., to the end bell or case of the motor.

G. All Test Reports shall list the design standard value, the actual recorded value and the acceptable range of values.

H. Certify by letter on Company letterhead, that all of the above testing has been successfully completed.

2.8 ELECTRICAL EQUIPMENT BY OTHERS:

A. All electrical equipment furnished and installed under other than Divisions 26, 27 and 28 will be furnished with the full complement of control equipment, starters, control wiring conduit and all other items necessary for satisfactory operation, unless specifically indicated otherwise on the Electrical drawings.

B. Provide disconnect switches for all motor driven equipment with starters not in sight of panelboard, except when combination motor starters are furnished under other Divisions or where packaged control panels are mounted on equipment by equipment manufacturer. Refer to schedules on HVAC and Plumbing drawings for such packaged systems provided with combination starters. Refer to the HVAC and Plumbing Specifications for packaged control panels. Provide disconnect switches at motors when motors are located out of sight of starters or where otherwise required by National Electrical Code. Disconnect switches shall be lockable in the off position.

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C. Mount all starters or unmounted control panels furnished by other Divisions and complete electrical power connections through the disconnect, starter and motor or other device terminals. Make all final power and other connections.

1. Where packaged control panels are furnished by other trades for equipment such as cooling towers, air handling units, package rooftop HVAC units, condensing units, or similar items, provide all wiring required to connect the motors, contactors, heating elements, sensors, etc., of that equipment to the central panel per wiring diagrams provided by the equipment manufacturer.
2. It shall be assumed that all wiring instructions provided by equipment manufacturers describe wiring methods, materials, and equipment that complies with the requirements of the National Electrical Code, latest edition. If any such given instruction is found to result in non-NEC compliant conditions, stop work and request direction from Design Professional.

D. Single phase motors integral with equipment (heat pumps, unit ventilators, unit heaters, VAV boxes, and similar HVAC equipment; sump pumps, circulators, and similar plumbing equipment) will be furnished with integral or equipment mounted overload heaters provided with the units. Provide a motor rated toggle-type disconnect switch for each unit where shown. If the motor or equipment does not have integral overload protection, the HVAC, Plumbing Contractor or equipment supplier will furnish a switch with thermal overload element(s) for installation by the Electrical Contractor.

E. Where equipment supplied by others is controlled by line-voltage devices (thermostats, speed controllers, timers, etc.), these devices will be furnished for mounting and wiring to the Electrical Contractor by the other trades. Refer to HVAC and Plumbing drawings as well as Electrical drawing for these devices. Install devices and make all final connections as may be required.

F. Complete all power wiring for single phase equipment, through the disconnect and/or the thermal cutouts and local control stations to the equipment, and make all final connections as required.

G. Certain equipment will be furnished and set in place by others. Obtain dimensioned equipment drawings, wiring diagrams, and other installation data as may be required to properly complete rough-ins and final connections.

H. Provide all rough-ins and make all final connections for the various electrical services required for all Owner furnished equipment. Obtain from Owner, dimensioned equipment drawings, wiring diagrams, and other installation data as may be required to properly complete rough-ins and final connections.

2.9 SUBSTITUTIONS:

A. Equipment may be shown or specified in several ways:

1. Several manufacturers and model numbers listed; or one manufacturer and model number, followed by "equals by (mfr A), (mfr B), (mfr C)," or words of similar respect:

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a. If one of the manufacturers is listed on the drawings, that manufacturer shall be considered the Basis of Design. If none is so listed, the first manufacturer named in the Specification shall be considered the Basis of Design, and one of the others listed may be considered as Substitutions.
b. Where manufacturer's or supplier's name, style and catalog numbers are mentioned in the description of material and equipment in the specifications or on the drawings, it is to be understood that they are for the purpose of setting a standard.
c. If Contractor elects to furnish equipment other than the Basis of Design, they shall verify and be responsible for capacities, physical size, weight, electrical requirements, methods of connection to other parts of the system, and all other relevant data.
d. Inform the Design Professional of all changes required to other equipment, spaces, structure or systems in order to install the substituted equipment. Furnish all required shop drawings or sketches required for Design Professional and the remainder of the Design Team to evaluate the required changes and shall be responsible for all costs associated with such changes, including costs of design or engineering, if such are necessary, and costs of other trades.

2. Where manufacturer's or supplier's names are listed in conjunction with the manufacturer or supplier that is Basis of Design, they are given to approve the firm name only. Equipment or material submitted by such firms must meet the detailed technical specifications written for the respective item. Contractor shall be responsible for verifying capacities, physical sizes, weights, electrical requirements, methods of connection to other parts of the system, etc. Contractor shall furnish all required shop drawings for equipment, and for its connection and installation.

B. If any substituted items are submitted after contracts have been awarded, and there is any question of equality of such items, samples may be required to be submitted both for the item specified and that to be substituted, or, further proof of equality may be required to the entire satisfaction of the Design Professional. In no case shall additional remuneration be allowed because of the rejection of a substitute.

C. When the equipment is relocated to a place other than that shown on the drawings, or when equipment other than that specified is used, the Contractor shall pay the extra cost of required revisions such as structural steel, concrete, electrical, piping, etc.

D. The Design Professional's costs to evaluate substitutions and to revise Drawings and Specifications because of substitutions will be paid by the Contractor.

2.10 SHOP DRAWINGS:

A. Prior to submission of any shop drawing submittals, and not more than thirty (30) days after award of the contract, submit to the Engineer, for approval, a complete list of all Sub-Contractors, Materials and Equipment Manufacturers proposed for the project. This list shall include the proposed manufacturer of all equipment proposed for the project; the local sales agency (not the distributor) for the lighting package, and the vendor for each special/low voltage system.

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B. No shop drawing submittals will be considered for review or approval until the complete lists of sub-contractors, and materials and equipment manufacturers have been received and approved by the Engineer.

C. Furnish shop drawings, catalog cuts, performance data and other required data to the Design Professional for approval for all material and equipment specified hereinafter. Sufficient data shall be submitted to show compliance with the requirements of the plans and specifications. All shop drawings submitted shall be first checked and corrected before submitting for approval. Approval for shop drawings by the Design Professional will not relieve the Contractor from responsibility for errors or omissions therein. All such errors or omissions must be made good by the Contractor irrespective of any approval by the Design Professional.

D. The following applies to all materials and equipment being submitted for this project. Refer to the individual specification sections for additional submittal requirements.

E. It is the responsibility of the manufacturer's representative and the installing contractor to thoroughly review all shop drawing equipment submittals and state in writing that the products meet or exceed the design specifications and design intent as indicated on the contract documents, prior to submitting them for review by the Engineer.

F. The General Contractor or Construction Manager shall review and stamp all shop drawings noting their review process has taken place and that the shop drawings are in compliance with the design documents, prior to submitting the for review by the engineer. Any shop drawings found to not be in compliance shall be returned to the contractor stating such, with a copy of the statement (only) forwarded to the engineer.

G. On submissions beyond the initial one, clearly identify all of the changes made from the initial submittal those requested by the Design Professional will review only those changes they requested and those identified by the Contractor.

H. The Engineer will review up to three (3) submissions (one original submission and up to two (2) revised submissions) on any single component requested for review. If the contractor and/or vendor fail to comply with the drawings, specifications, and/or review comments and additional submissions are required, the cost for review and processing of those submissions will be borne by the contractor, OR if, in the Engineers opinion, it is felt that the submitted equipment cannot meet the project requirements, the Basis of Deign equipment shall be provided at no additional cost.

I. The design documents are based and coordinated on the scheduled manufacturers. Any substitutions of products or materials (from those approved and listed in the specifications) must be thoroughly coordinated by the submitting contractor. This includes but is not limited to power, space, structural, control and performance requirements.

J. Prepare and submit detailed dimensioned shop drawings, together with wiring diagrams, specifications, and operating data, for all specifically fabricated or designed equipment modified from standard items. Shop drawings shall include, but are not necessarily limited to, the following equipment or systems:

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Equipment or System	Include in List of Manufacters	Catalog Data Sheets	Detailed Quantity Take-Off	Dimension Shop Drawings	Special Systems Drawings	Comments
Branch Circuit Panelboards	X	X	X			
Distribution Panelboards	X	X	X	X		
Switchboards	X	X	X	X		
Surge Suppression Devices (SPD)	X	X	X			
Fuses and Circuit Breakers	X	X	X			
Dry Type Transformers (600 volts & below)	X	X	X	X		
Disconnects (Safety Switches)	X	X	X			
Conduits and Raceways	X					
Outlet Boxes	X					
Pull Boxes, Wire Troughs	X					
Wire and Cable (600 Volt & below)	X					
Wiring Devices	X	X				
Time Clocks	X					
Grounding	X					
Sleeves, Hangers, Supports	X					
Lighting Fixtures and Lamps	X	X	X			
Fire Alarm and Signaling System	X	X	X		X	
Generator(s)	X	X		X		
Automatic and Manual Transfer Switch(es)	X	X	X	X		

1. Prepare Special Systems Drawings for each of the low voltage systems specified in Divisions 27 and 28. These shall include, but are not necessarily limited to:

   a. Fire Alarm and Detection System
   b. Security Systems:

      1) Intrusion Detection System
      2) Access Control System
      3) Video Camera/Monitoring System

   c. Sound Systems
   d. Nurse Call System
   e. Television Signal Distribution System

2. The Special Systems Drawings shall be of the same size as the contract drawings, and shall consist of plans of the building, drawn to an appropriate scale. These drawings shall consist of original drawings prepared by the Contractor and shall not consist of marked-up prints of contract drawings. All system devices, and their interconnecting wiring and raceways shall be indicated on the drawings. The drawings shall show each device in the project, along with the room name and number in which it occurs, the type and mounting of the device, and the zone or system address of the device as appropriate to the specific

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system. Each system shall be drawn on a separate set of drawings. These drawings shall indicate installation details, raceway routing, wiring quantities and sizes, wiring connections, wiring color codes and system configuration.

3. The drawings shall be prepared using BIM360 Revit 2022 for use in a Microsoft Windows 10™ operating environment. The project design files will be provided to the Contractor by the Design Professional following proper execution of the Document Release and Indemnity Form as provided by the Design Professional.
4. At the completion of the project, all Special Systems drawings shall be brought fully up-to-date to indicate all as-built conditions, including field modifications, conduit routings, wiring connections, etc. Room names and numbers shall reflect actual project room signage and designations, which may be different from room indications shown on the contract drawings.
5. Full size prints of these As-Built drawings shall be included in the building Operation and Maintenance Manuals, along with electronic copies in PDF format.
6. The original files prepared in (Revit *.rvt file format) software shall be turned over in their editable native electronic format as part of the project close-out documents.

K. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristic, finishes for materials, and installation and startup instructions for each type of product indicated.

L. Each control device labeled with setting or adjustable range of control.

M. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Schematic flow diagrams showing all controlled equipment and control devices.
2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
3. Details of control panel and equipment rack faces, including controls, instruments, and labeling.
4. Written description of sequence of operation.
5. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
6. Listing of connected data points, including connected control unit and input device.
7. System graphics indicating monitored systems, data (connected and simulated) point addresses, and operator notations.
8. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.

N. Shop Drawings shall be submitted and shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Shop drawings shall also contain complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, calculations, and any other details required to demonstrate that the system will function properly. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work.

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O. Shop Drawings shall be approved before any equipment is installed. Therefore, shop drawings must be submitted in time for review so that all installations can be completed per the project completion schedule. Ten (10) working days shall be allowed for submittals to be reviewed.

P. All drawings shall be reviewed after the final system checkout and updated or corrected to provide "as-built" drawings to show exact installation. All shop drawings will be acknowledged in writing before installation is started and again after the final checkout of the system. The system will not be considered complete until the "as-built" drawings have received their final approval. The Contractor shall deliver a complete set of "as-built" drawings.

Q. On submissions beyond the initial one, clearly identify changes made from the initial submittal other than those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.

R. If the Contractor elects to proceed to install equipment for which approved Shop Drawings have not been received, they do so at their own risk; the Owner and Design Professional are not obligated to accept such equipment or work, nor will the Owner or Design Professional be liable for claimed costs or delays required by correction of such work.

S. Shop Drawing Review Comment Definitions:

A> No Exception Taken:

The shop drawing or equipment submittal as submitted is approved without exception. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

B> Make Corrections Noted:

The shop drawing or equipment submittal as submitted is not completely correct but is approved as noted. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted can be released for fabrication and construction once the corrections have been made. The submittal must be corrected and resubmitted for record unless noted by "E: Resubmit". See "E: Resubmit definition below.

C> Submit Specified Item:

The shop drawing or equipment submittal as submitted is missing a component of the system that it represents or is not of the approved and specified manufacturers. Submit the missing or incorrect item. The materials, equipment or system submitted cannot be released for fabrication and construction.

D> No Further Submission Required:

The shop drawing or equipment submittal as submitted is approved as noted. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

E> Resubmit:

The shop drawing or equipment submittal as submitted is not approved. The shop drawing or equipment submittal needs significant corrections and does require another submission to verify that the comments and changes have been incorporated. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted cannot be released for fabrication and construction.

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F> Rejected:

The shop drawing or equipment submitted is not as specified or a non-approved manufacturer or product and rejected.

G> Resubmit for Record Only:

Make the corrections noted on the shop drawing or submittal. The shop drawing or equipment submittal as submitted is approved with minor exception. Changes or corrections are required. The materials, equipment or system submitted can be released for fabrication and construction.

T. Refer to the Project General Conditions and Division 01 Requirements for additional shop drawing submittal requirements, as well as specific requirements in various Divisions 26-28 Technical Specifications.

PART 3 - EXECUTION

3.1 VISIT THE SITE PRIOR TO PLACING BID:

A. Visit the site and observe the conditions under which the work shall be performed or other circumstances which will affect the contemplated work.

B. Bidders shall thoroughly familiarize themselves with all installation parameters, including means and methods of getting equipment and materials into and out of the facility.

C. No subsequent allowance will be made for any error, omission or negligence on the Contractor's part.

3.2 WORKMANSHIP:

A. All work shall be installed in a first class, neat and workmanlike manner by mechanics skilled in the trade involved. All details of the installation shall be mechanically and electrically correct. Should the Design Professional direct removal, change, or installation of any equipment or systems not installed in a neat and workmanlike manner, such charges shall be made by the Electrical Contractor at no expense to the Owner.

B. Equipment shall be installed in strict accordance with manufacturer's instructions for type and capacity of each piece of equipment used. The Contractor shall obtain these instructions from the manufacturer and these instructions shall be considered part of these Specifications.

C. Drawings are generally indicative of the work to be installed, but do not indicate all conduit bends, fittings, pullboxes, and specialties which may be required, or the exact locations of all conduits. Investigate structure and finish conditions affecting the work, along with the work installed by other trades and arrange the work; accordingly, furnish such fittings and appurtenances as may be required to meet such conditions. Contractor is responsible for exercising proper judgment to arrange their work and materials so as to avoid interference with other trades.

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1. The essentially diagrammatic nature of drawings shall not be interpreted as reason to redesign project. While raceways or cables shall be installed as required by local conditions rather than exactly as may be shown, all outlets indicated on one circuit shall be so installed. No reduction in size or number of raceways or cables will be permitted. In general, quantity of wires in each raceway or cable has not been indicated but shall be provided as required.
2. Riser and one line diagrams, details, and schematics generally indicate wiring to be used in various systems involved. This information may or may not be duplicated on the plans, but equipment shown on either plans or Riser or One Line diagrams and schematics shall be provided as if shown on both.
3. All grades, elevations, dimensions and clearances of equipment shown on drawings are approximate and shall be verified at site.
4. Where work or equipment is referred to in singular terms, such reference shall be deemed to apply to as many items of work or equipment as required to complete entire installation.

D. Electrical junction boxes, pull boxes, panel boards, switches and controls and other apparatus requiring periodic maintenance and operation shall be accessible.

3.3 LINES AND GRADES:

A. A competent Electrical Foreman shall be on the premises at all times during the construction to check, layout, coordinate and superintend the installation of the work performed under Divisions 26-28. Submit a complete resume for the foreman proposed for this particular project, along with a list of at least ten (10) similar projects, including construction dates and Owner's contact information (name, organization, address, telephone and email). The foreman shall be approved by the Construction Manager or General Contractor, the Owner and the Design Professional prior to start of construction.

B. Establish all grades and lines relative to the work before any work has been started and be responsible for the accuracy thereof.

C. Lay out work and establish heights and grades for work in strict accordance with the intent expressed by the drawings and all the physical conditions at the building and be responsible for the accuracy of same.

3.4 FIELD MEASUREMENTS:

A. Before ordering any material or doing any work, verify all measurements at the building and site and be responsible for the correctness of same. No extra compensation will be allowed on account of differences between actual dimensions and measurements and those indicated on the drawings. Any difference which may be found shall be submitted to the Design Professional for consideration before proceeding any further with the work.

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3.5 DELIVERY OF EQUIPMENT:

A. Be responsible for delivery of equipment, unload and store in a manner not to interfere with the operation of other trades. Additional expense incurred because of equipment or material delivery delays shall be assumed by the responsible Contractor.

3.6 RESTRICTIONS ON EARLY USE OF ELECTRICAL EQUIPMENT:

A. Any electrical equipment placed into service and used prior to project Substantial Completion shall be used at the onus of the contractor and they shall assume full responsibility for repairing or replacing any equipment damaged as a result of the use and pay all costs associated with the action required to restore the equipment to "like new" condition at the end of the project. This includes extension of warranties, payment of Design Professional fees required to investigate and enforce this requirement, and the correction of any other detrimental conditions which is determined by the Design Professional to be related to the early use of the equipment.

B. Should the early use of equipment result in manufacturer's warranty being void or of limited duration, the contractor shall assume the cost of furnishing an equivalent warranty to the Owner. Refer to Article "Warranty" in Part 1 above.

3.7 PROTECTION OF WORK:

A. All work, equipment and materials shall be protected at all times. All raceway openings shall be closed with caps or plugs during the installation. All equipment shall be tightly covered and protected against dirt, water, plaster, paint and other foreign material or mechanical injury during entire progress of installation. Make good all damage caused either directly or indirectly by workmen employed to fulfill requirements of the Electrical Work.

3.8 REMOVAL OF RUBBISH:

A. During the course of construction, periodically remove from the premises all trash, rubbish and miscellaneous debris resulting from work of this trade so as to prevent its accumulation. At the completion of the work contemplated under these Specifications remove from the building and site all rubbish and accumulated materials of whatever nature not caused by the other trades and leave work, and equipment free of all foreign matter including plaster, cement, and paint and leave in a clean, orderly, acceptable and usable condition.

3.9 COORDINATION WITH OTHER TRADES:

A. Coordinate the entire electrical installation with the work of all other trades on the project to provide a fully coordinated installation, with proper access to all equipment requiring same, proper electric service to each piece of equipment requiring electrical power and proper provisions for servicing and maintenance of all equipment of all trades. Install electrical raceways and equipment to minimize interference with other trades and allow proper access to all equipment of all trades. Follow National Electrical Code requirements for equipment access and clearances.

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B. Coordinate installation of electrical fixtures and devices in the ceiling with the Reflected Ceiling Plans, including Reflected Ceiling submittals where provided. Verify ceiling types and provide all required accessories, mounting hardware, trims and miscellaneous hardware for proper installation and support of each fixture or device in the ceiling type it is to be installed. Where fixtures or devices do not occupy a full ceiling tile, center the fixture or device within the individual ceiling tile in which it occurs. In no case shall electrical devices be supported solely by the ceiling tile or ceiling finish material. Provide suitable mounted brackets or hardware for support of the device by the ceiling support system and provide additional support wires from the building structure to prevent sagging or decoupling of the ceiling system. Coordinate all ceiling mounted devices, including those of other trades. The order of precedence for locating ceiling devices shall be generally as follows:

1. Building Structure
2. Bulkheads and Architectural Features
3. Exit Signs
4. Lighting Fixtures
5. HVAC Air Devices
6. Sprinkler Heads
7. Fire Alarm Devices
8. Speakers
9. Other devices

Where conflicts in the above order of precedence exist, they shall be brought to the attention of the Design Professional for resolution.

C. Coordinate locations of wall mounted devices with chalk and tack boards, projection screens or video equipment, casework, countertops, artwork and other architectural appurtenances. Refer to Architectural plans and elevations for additional information. Locate lighting control devices on latch side of door. Verify all door swings with the Architectural drawings prior to rough in. Verify casework and countertop arrangements with approved casework shop drawings.

D. Do not depend solely on the electrical drawings to determine building construction arrangements including, but not limited to, ceiling types, door swings, wall types, and structure. Verify actual conditions base on the individual discipline documents, approved submittals and approved equipment cuts.

E. Wherever possible obtain approved submittals for all equipment to confirm electrical power requirements and rough-in locations prior to installation of rough-ins.

F. Minor relocations of outlets, devices, fixtures and rough-in locations is to be expected prior to rough-in and shall be accommodated at no additional cost.

G. Participate in on-going contractor coordination efforts in order to create a finalized, well-coordinated layout of all equipment, fixtures, devices, raceways and all other items within their respective scope. The coordination effort shall include coordinating information from all other trade contractors involved in the project scope and all new work in order to provide a complete and thorough coordination effort. Any work which must be modified due to lack of coordination shall be the responsibility of the Contractor and shall be corrected at no additional cost to the project. Minor relocations and shifts of equipment and raceways, which do not change the design intent indicated on the contract documents, required to accommodate field

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conditions, and which do not involve changes in project cost or schedule, may be made at the Contractor's discretion and do not require Design Professional's approval.

H. Room names and numbers used in final As-Built/Record documentation shall be based on actual room names and numbers in use at the facility and are not necessarily those shown on the contract documents.

3.10 COORDINATION DOCUMENTS:

A. Participate in creation and maintenance of working Revit construction model. At the start of construction, following proper execution of a Document Release and Indemnity Form provided by the Design Professional, the Design Professional will provide copies of the Revit Model to the Contractor for their use in creating these working construction documents. These documents shall be created in the latest version of Revit software in the native Revit *.rvt file format. These shall be used to update the contract drawings for use as working Coordinated Installation Documents.

B. Periodic Contractor Coordination Meetings will be held under the supervision of the Construction Manager for the purpose of exchanging coordination information, resolving installation conflicts, laying out the exact location and routing of their work and updating the Revit model as working Coordinated Installation Documents. Each trade shall have proper representation at all Coordination Meetings. After the conclusion of the coordination at the working meetings, each trade shall update the working Installation Documents, and the updated Coordinated Installation Documents shall be posted to a project website hosted by the General Contractor or Construction Manager.

C. Throughout the construction of the project, the BIM Model shall be maintained at LOD (Level of Detail) 400 per BIM Forum, Level of Development Specification 2015, (https://bim-international.com/wp-content/uploads/2016/03/LOD-Specification-2015.pdf). As equipment submittals are approved, the BIM Model shall be rough up to date using Revit families obtained from the approved equipment manufacturers. This shall include, but is not necessarily limited to: Switchgear, switchboards, panelboards, disconnect switches, enclosed circuit breakers, motor starters, variable frequency drives, control panels, equipment cabinets, lighting fixtures, etc. The actual routing of conduits 2" and larger shall be shown including all pull and junction boxes, offsets, bends, etc.

D. Dimensioned layout plans of equipment rooms shall be provided showing all equipment, housekeeping pads, major pullboxes and raceways; suitable for coordination with other trades.

E. Furnish all necessary templates, patterns, etc. for installing work and for purpose of making adjoining work conform, furnish setting plans and shop details to other trades as required.

F. At the completion of the project, immediately following Substantial Completion, the BIM Model shall be brought to a final LOD 400 status, and electronic files of the completed model shall be provided to the Design Professional and Owner.

G. The drawings and model development for the project is based on specific equipment and materials, as the Basis of Design. This equipment and materials have been developed, designed, and graphically represented within the model, such that the quality, size, shape, location and

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orientation can be determined and measured. Non-graphic information may also be attached to the model element. The model does not fully resolve all minor spatial conflicts. The Contractor may utilize the model in developing his/her construction level drawings as well as shop drawings and submittals. The contractor shall update the spatial requirements of the equipment and materials, based on his/her final approved vendor selections and interdisciplinary coordination.

3.11 COORDINATION OF ELECTRICAL CHARACTERISTICS:

A. It is the intention and requirement of this specification that the proper electrical service be provided to all pieces of equipment on the project requiring same. As far as is possible, the proper service to each piece of equipment has been indicated on the plans. Verify the service requirements of all pieces of equipment before making final provisions. All manufacturer's details shall be available for check before installation. Check the exact point of connection for each piece of equipment so that the service may be brought to the proper location. Locations indicated on the plans are diagrammatic and approximate only.

B. Carefully examine the drawings of all other trades for equipment requiring electrical connection to confirm that all electrical characteristics of equipment indicated thereon matches the service available. Wherever possible, obtain approved shop drawings and equipment rough-in drawings for the actual item of equipment to be installed prior to rough-in. This shall apply to all equipment, whether it is to be installed by the contractor or by the Owner.

C. If any discrepancies are noted, immediately notify the Design Professional and request resolution. If characteristics are correct, Electrical Contractor is responsible for ascertaining method of connection, "rough-in" dimensions, correct plug and receptacle configurations, etc. While Design Professional has made every effort to provide such information as is known at time of design, Contractor shall obtain final data from approved shop drawings before proceeding.

D. For all equipment of other trades which electrical characteristics are not indicated on the drawings of that trade, notify the Contractor furnishing such equipment as to the characteristics required.

E. Prior to purchase and installation of any motor control equipment (starters, etc.), verify the actual motor electrical characteristics with the approved equipment shop drawings. Starter overloads shall be sized in accordance with actual motor nameplate running load amperes.

3.12 FIRE STOPPING:

A. Coordinate with the Architectural drawings to determine specific fire and smoke penetration ratings of building structural elements. Electrical work shall be installed so as to maintain the fire and smoke penetration ratings of walls and floors through which they enter or pass.

B. All penetrations through fire-resistance-rated floor, fire resistance rated, floor/ceiling assemblies and roof construction and through fire-resistance-rated walls and partitions shall be fire stopped.

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C. Firestopping materials shall be UL tested and listed as suitable for the specific installation arrangement for which it is to be used. The material shall possess intumescent characteristics and upon exposure to heat above 250 degrees F. shall expand to not less than five times its original volume to fill all voids and form a fireproof envelope, UL rated for 2 and 3 hour protection, when applied in accordance with the manufacturer's recommendations. Firestopping material shall be impervious to water and similar liquids. Sodium silicate based firestopping materials are not acceptable.

D. Conduit: The annulus between exposed conduit and walls or floors in finished spaces shall be filled, sealed, and painted or otherwise finished to match adjacent surfaces. Single or multiple conduits passing through or entering walls and floors shall have the annulus space between conduits or between conduits and structure filled with firestopping material which maintains the fire rating of the wall or floor.

E. Future Slots: Identify unused sleeves and slots for future use by permanently anchored nameplates identifying size and purpose of the covered slot.

F. Large Openings: Large openings in walls or floors shall be infilled with material to match the surrounding building surfaces. Provide suitable studs, angles, beams, lintels etc. as may be required to adequately support infill materials. Allow 1" space between structural infill materials and conduits, cables and electrical work passing through or entering walls or floor slabs. Fill all spaces around conduits, cables and electrical work with intumescent firestopping material as specified above.

G. Fire rating of sealed penetrations shall meet or exceed the rating of the assembly being penetrated.

H. Firestopping materials shall be installed in accordance with manufacturer’s recommendations and their UL listing.

I. Refer to Division 07 Section, “Firestopping” for additional information and requirements.

J. Edit or delete this section below if the architect is handling Access Devices

3.13 ACCESS DEVICES:

A. Access doors shown on the Architectural Drawings will be provided under the Architectural Sections of the specification. All other access panels shall be furnished by the Contractor responsible for the work specified under Divisions 26, 27 and 28 of the specifications, for installation under this Section of the specifications, in accordance with the requirements specified herein.

B. Access panels shall be provided for access to all concealed equipment, junction boxes, control devices, disconnects and other devices above non-accessible ceilings, in vertical chases, or where no other means of access is available. Final size and location of access panels shall be subject to approval by the Design Professional. Cooperate with all other trades so that equipment will be properly accessible through the access panels.

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C. Access doors in surfaces which are fire rated shall be Nystrom Uninsulated Fire-Rated Access Door or approved equal. Provide flange trim as required to suit the wall finish into which it is being installed. Fire Rated Access Doors shall be prime coated. Provide each Fire Rated Access Doors with any other accessories as required. The fire rating shall match the fire rating of fire rated assembly.

D. Non-fire rated access panels shall be of steel construction, prime coated, shall have front panel fitted flush with the frame, with concealed hinge and latches; and shall be Milcor, Style K or M, or as required to accommodate the adjacent wall and ceiling construction, or equivalent as manufactured by Inland Steel Products Co., Miami-Carey Division of the Philip Carey Mfg. Co., Newman Brothers, Inc., Cesco Products or Larsen's Manufacturing Company.

E. Provide all access doors (fire rated or not) with mortise lock, keyed as directed by Owner, and any other accessories as required.

F. Access panels and doors shall be minimum 14" x 14". Final size and location of access panels shall be subject to approval of the Engineer. Cooperate with all other trades so that equipment will be properly accessible through the access panels.

3.14 SHORT CIRCUIT, COORDINATION AND ARC FLASH STUDY:

A. Provide the services of a firm qualified and experienced in Short Circuit/Coordination and Arc Flash studies to perform a Study on the entire electrical power distribution system in this facility following the approval of circuit protective devices and power distribution equipment. All costs associated with the preparation and updating of the Study to reflect final, as-built project conditions shall be included by the Contractor in their bid.

B. Include an allowance in the contract cost to change and/or upgrade 25% of the overcurrent protective devices and power distribution equipment to a higher A.I.C. rating and/or different style overcurrent protective device type, to include fuses or relays, as required by the results of the Short Circuit, Coordination and Arc Flash Study for the available fault currents, to provide proper coordination of devices or to reduce arc flash hazards. Where circuit breaker type overcurrent protective devices do not provide proper device coordination, replace circuit breaker type devices with fuse type devices to allow proper coordination. Changes required to meet findings of the Short Circuit, Coordination and Arc Flash Study shall be made at no additional cost to the Owner.

C. Refer to Section 260573 Power System Studies for additional information and requirements.

D. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from engineer for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory. Any remediation on gear that requires changes but released without the engineer’s approval is the full responsibility of the contractor.

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3.15 OWNER'S INSTRUCTIONS:

A. Upon completion of all work provided under these Divisions of the specifications, thoroughly instruct the Owner's representatives in the operation and maintenance of all the various apparatus and equipment to the approval and complete satisfaction of the Engineer. This shall be done after the completed systems have been put in full operating condition and all tests are successfully completed.

1. Refer to additional Instructional requirements in the various specification sections of Divisions 26, 27, and 28.

B. Provide factory trained and certified instructors for each training session.

C. Provide sufficient copies of all training materials, hand-outs, manuals, etc. so that each person in attendance has a copy of all materials.

1. Utilize professional quality video camera(s). Cell phone and similar cameras are not acceptable.
2. Utilize remote microphones as may be required to ensure high quality audio of the recorded demonstrations.
3. Sessions shall be recorded digitally, and the recordings shall be provided to the Owner in standard digital format, viewable on a computer running the Microsoft Windows operating system. Close-out the recording session and create file index with each pertinent point in the session indexed. Verify compatibility/functionality prior to submitting to the Owner.
4. Provide three (3) copies of each digital recording for the Owner's record.

END OF SECTION 26 00 00

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SECTION 26 00 05

COORDINATION DRAWING REQUIREMENTS FOR ELECTRICAL

PART 1 – GENERAL

1.1 COORDINATION DRAWINGS

A. All mechanical, electrical, plumbing, fire protection, telecommunications, and ATC subcontractors will be required to use AutoCad (CAD) or 3D BIM format. Coordination drawings will be distributed via email and/or disk.

B. For 3D BIM projects, the CM/GC shall hold BIM coordination meetings with all trades to resolve conflicts and to coordinate the installation layouts. The BIM coordination meetings shall be at a frequency necessary to complete the overall coordination tasks and efforts.

C. The drawings and model developed for the project is based on specific equipment and materials, as the Basis of Design. This equipment and materials have been developed, designed and graphically represented within the model, such that the quantity, size, shape, location and orientation can be determined and measured by the contractor. Non-graphic information may also be attached to the model element. The model does not fully resolve all minor spatial conflicts. The Contractor may utilize the model in developing the his/her construction level drawings as well as shop drawings and submittals. The contractor shall update the spatial requirements of the equipment and materials, based on his/her final approved vendor selections and interdisciplinary coordination.

1.2 ABOVE CEILING AND NO CEILING OVERHEAD INSTALLATION

A. The Mechanical Contractor shall furnish minimum 1/4" scale CAD electronic background drawings of the sheet metal shop drawings, for incorporation of plumbing and mechanical piping services. All ductwork and piping systems shall be thoroughly dimensioned as to location and height above finished floor. Each different system will be drawn in a different color. Upon conclusion of the various systems coordination with the Sheet Metal Contractor, the composite drawing shall be distributed by the Construction Manager for contractor coordination. All lighting fixture locations will be "ghosted in" by the Sheet Metal Contractor for coordination of the same. The Sheet Metal Contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the Sheet Metal, HVAC Piping, Plumbing, Fire Protection, Electrical, Telecommunications and ATC firms, with the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

NOTE: The composite drawing is in addition to separate shop drawings to be submitted at the conclusion of the coordination process.

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B. At the conclusion of each composite drawing coordination process, the Construction Manager shall be notified by the Mechanical Contractor Project Manager. The Mechanical Contractor Project Manager shall then schedule an on-site coordination meeting for the purpose of signing off on the respective drawing. The Mechanical Contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.

C. The Mechanical Contractor shall print a weekly status log and maintain a file for the project on this process. Each subcontractor is responsible to submit and coordinate his work with the Construction Manager and Mechanical Contractor.

D. The Fire Protection Contractor shall overlay his complete piping system on a composite background drawing furnished by the Mechanical Contractor. The Fire Protection Contractor shall utilize a different color from that previously used by the HVAC and Plumbing draftsmen. The Fire Protection Contractor shall cooperate in the coordination process by the relocation of his piping as required to facilitate coordination. When completed, Sprinkler Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the entire coordination process, the Fire Protection Contractor shall be responsible for attending a coordination meeting at the jobsite for the purpose of his authorized personnel affixing their signatures to the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."
>
> NOTE: The composite drawing is in addition to a separate sprinkler piping shop drawing to be submitted at the conclusion of the coordination process.

E. The Electrical Contractor shall be responsible to overlay his major conduit racks and equipment, as well as verifying all lighting fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. All conduits larger than 2" shall be documented. When completed, Electrical Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Electrical Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of his authorized personnel affixing his signature to the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

F. The Plumbing Contractor will be responsible to overlay his major piping racks and equipment, as well as verifying all plumbing fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Plumbing Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Plumbing Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of his authorized personnel affixing his signature to the statement below:

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"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

G. The Telecommunication Contractor will be responsible to overlay his major communication racks and cable tray, as well as verifying locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Telecommunication Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Telecommunication Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of his authorized personnel affixing his signature to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

H. Provide survey and coordination of underground plumbing for verification of location.

I. Drawings, if available, may be obtained electronically from the Architect through the Construction Manager.

J. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall receive hard copies of all drawings.

K. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall review all drawings and advise if any additional drawings are needed.

L. The Mechanical Trade Contractor shall take the lead and develop a drawing list for submissions and a submission schedule coordinated with the construction activities. The drawings shall be developed in a sequential fashion so as to no delay installation of the work or the overall project schedule. The lead Mechanical trade contractor shall include a master key plan so that the area of each drawing can be readily identified as to the location within each building. The Plumbing trade contractor shall lead the underground coordination and the HVAC trade contractor shall lead the balance of the coordination work. The drawing list and schedule shall be forwarded to the Construction Manager for review.

M. Pursuant to Construction Manager approval of the list and schedule, the Mechanical trade contractor shall provide to all participants the latest plans in a timely fashion in accordance with his schedule.

N. Prior to the start of the work, each subcontractor shall forward an insulation schedule to the Construction Manager M.E.P. Coordinator. The schedule shall show the size and thickness of each type of insulation and its intended use.

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1.3 SHEET METAL / PIPING / ATC / ELECTRICAL ACCESS / MAINTENANCE CLEARANCES

A. As soon as practical, the Mechanical trade contractor shall prepare layout drawings (not less than 3/8" scale) of all ductwork and piping. These drawings shall show all WALL FIRE RATINGS, registers, grilles, diffusers and similar features, as well as locations of all valves, dampers, damper operators and other items requiring access for maintenance. It shall also be the responsibility of the Mechanical trade contractor to show on these drawings; beams with bottom elevations, ceiling heights, wall-to-wall dimensions, partitions, columns, windows, doors, electric lighting layouts as shown on the reflected ceiling plans, acoustical ceiling grid, and other major architectural and structural features as shown on the General Construction Drawings. All dimensions should be from centerlines of columns. All required access to equipment for service and/or required for NEC code required clearances shall be shown in a dotted zone.

B. The Mechanical trade contactor, upon completion of his work, shall email his data back to the Plumbing trade contractor and copy all participants. The Plumbing trade contractor shall download the mechanical data and incorporate, by separate layer, his own routing, as well as other areas requiring access for service and maintenance to determine their relationship and possible interferences with the mechanical, architectural or structural features to be performed as part of the work.

C. The Plumbing trade contractor shall then email his data to the Electrical trade contractor and copy all participants. The Electrical trade contractor shall download the drawing and incorporate, by separate layer, his own routings, as well as the depth of all light fixtures, access panels, etc., as required to determine the relationship and possible interferences with plumbing, mechanical, architectural or structural items to be installed as part of the overall work. The Electrical trade contractor shall be responsible to verify that the electrical lighting layout shown on these drawings is correct and to make corrections and additions of all other light fixtures as required. In areas where no mechanical work occurs, but where other crowded electrical installations are evident, the Electrical trade contractor shall prepare similar drawings.

D. The Electrical trade contractor shall then email the Fire Protection trade contractor and copy all participants. The Fire Protection trade contractor shall download the drawing and incorporate, by separate layer, his own routings, as well as other areas requiring access for service and maintenance, to determine their relationship and possible interferences with the mechanical, electrical, plumbing and architectural or structural items to be installed as part of the overall work.

E. The Mechanical trade contractor shall provide one composite set of reproducible drawings and forward them to the Construction Manager. This composite shall then be reviewed during meetings determined by the Construction Manager, at which all subcontractors including their subcontractors, as required by the Construction Manager, shall be represented to review and resolve any real or apparent interference or conflicts.

F. In the preparation of all the final composite drawings, large scale details, as well as cross and longitudinal sections shall be made as required to fully delineate all conditions. Particular attention shall be given to the locations, size and clearance dimensions of equipment items, shafts and similar features. The final composite drawings shall include the locations of all controls, tie-ins, connections for other subcontractor's work, and pipe and duct insulation as required.

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G. Final composite drawings shall then be signed off by each trade subcontractor indicating their acceptance and approval of the indicated routings and layouts and their relationship with the adjoining or contiguous work of all subcontracts. Thereafter, no unauthorized deviations shall be permitted. If deviations are made without the knowledge and agreement of Construction Manager and other affected trade contractors, the work in question shall be subject to removal and correction at no additional cost.

H. In preparing the composite drawings, minor changes in duct, pipe or conduit routings that do not affect the intended function may be made as required to avoid space conflicts, when mutually agreed. Items may not be resized, exposed items relocated, or items run exposed when not intended, without approval. No changes shall be made in any structural members or architectural features which affect the function or aesthetics of the buildings. If conflicts or interferences cannot be satisfactorily resolved, the Engineer shall be notified, and his decision obtained.

I. After final composite drawings have been accepted and approved, and signed by ALL subcontractors, the Mechanical trade contractor shall provide and distribute one sepia and two prints to each of the subcontractors, and one sepia and four prints each to Construction Manager. Subcontractors requiring further prints for their own distribution will possess sepias to accomplish same. The original signed-off mylars shall be sent to Construction Manager for permanent possession.

J. The record copies of final composite drawings shall be retained by each subcontractor as a working reference. All shop drawings, prior to their submittal to Construction Manager, shall be compared with the composite drawings and developed accordingly by the subcontractor responsible. Any revisions to the composite drawings, which may become necessary during the process of the work, shall be noted by all subcontractors and shall be neatly and accurately recorded on the record copies. Each trade contractor shall be responsible for the up-to-date maintenance of his own record copies of the composite drawings and to keep one copy available at the site. The composite drawings and any subsequent changes thereto, shall be utilized by each subcontractor in the development of his as-built drawings. NOTE: The coordination drawings may be used with appropriate changes as as-builts and changes to title block.

K. Preparation of coordination drawings shall commence as soon as possible after award of the subcontract. The coordination drawings may lack complete data in certain instances pending receipt of equipment drawings, but sufficient space shall be allotted for the items affected. When final information is received, such data shall be promptly inserted on the composite by that trade contractor.

L. Coordination is the responsibility of all trade contractors. Construction Manager will call meetings, weekly, or as required, which subcontractors must attend to avoid delay. Failure to attend shall require the trade contractor to field run the work not coordinated. No extra compensation will be paid to any trade contractor for relocating any duct, pipe, conduit or other material that has been installed without proper coordination. If the installation of any uncoordinated work or improper installation or coordinated work necessitates additional work by other subcontractors, at the cost of such additional work shall be assigned to the trade contractor responsible as determined by Construction Manager.

M. All changes in the work of any subcontract shall be shown on the composite drawings.

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N. All work on the coordination composite drawings shall be performed by competent CAD/BIM operators, in a clear legible manner. Each trade contractor shall execute a typical drawing activity in no more than three working days. It shall be the responsibility of each subcontractor to supply a sufficient number of CAD/BIM operators so as not to delay the coordination process. Construction Manager and Engineer shall be the judge of the acceptability of the drawings.

O. The composite drawings shall not be used for as-built drawings. (See Paragraph above)

P. It shall be further understood that each trade contractor's specified submittals shall be transmitted for approval during the coordination period in order that the project encounter no delays.

Q. The Mechanical trade subcontractor shall pre-coordinate all control equipment locations with the designated ATC trade subcontractor and indicate it on the composite document.

1.4 REQUIREMENTS

A. All Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC trade contractors shall be required to use AutoCad (CAD) or 3D BIM format. Coordination drawings shall be distributed via email or diskettes. ALL EMAILS SHALL BE COPIED TO CONSTRUCTION MANAGER, ENGINEER, AND PROJECT MANAGER.

B. The Sheet Metal trade contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the sheet metal, HVAC, piping, plumbing, sprinkler, electrical and ATC firms with the statement below:

> "The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

C. The Mechanical trade contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.

D. The Mechanical Contractor shall print a weekly status of all emails sent and received and maintain a hard copy file for use at the coordination "sign-off" meetings. Each subcontractor is required to check emails daily.

E. Submittals: Once the coordination process has been completed, the coordination drawings shall be submitted to the Engineer for review. A single-color plot, as well as three blue print copies of the drawings shall be submitted for review. The color plot shall delineate between the various disciplines by utilizing different color pens for each system.

PART 2 – PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION (NOT APPLICABLE)

END OF SECTION 26 00 05

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SECTION 26 00 10

SUPPLEMENTAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies supplemental requirements generally applicable to the Work specified in Division 26. This Section is also referenced by related Work specified in other Divisions.

B. Related Requirements:

1.2 REFERENCES

A. Abbreviations and Acronyms for Electrical Terms and Units of Measure:

1. 8P8C: An 8-position 8-contact modular jack.
2. A: Ampere, unit of electrical current.
3. AC or ac: Alternating current.
4. AFCI: Arc-fault circuit interrupter.
5. AIC: Ampere interrupting capacity.
6. AL, Al, or ALUM: Aluminum.
7. ASD: Adjustable-speed drive; also called "variable-frequency drive" (VFD).
8. ATS: Automatic transfer switch.
9. AWG: American wire gauge; see ASTM B258.
10. BAS: Building automation system.
11. BIL: Basic impulse insulation level.
12. BIM: Building information modeling.
13. CAD: Computer-aided design or drafting.
14. CATV: Community antenna television.
15. CB: Circuit breaker.
16. cd: Candela, the SI fundamental unit of luminous intensity.
17. CO/ALR: Copper-aluminum, revised.
18. COPS: Critical operations power system.
19. CU or Cu: Copper.
20. CU-AL or AL-CU: Copper-aluminum.
21. dB: Decibel, a unitless logarithmic ratio of two electrical, acoustical, or optical power values.
22. dB(A-weighted) or dB(A): Decibel acoustical sound pressure level with A-weighting applied in accordance with IEC 61672-1.
23. dB(adjusted) or dBa: Decibel weighted absolute noise power with respect to 3.16 pW (minus 85 dBm).
24. dBm: Decibel absolute power with respect to 1 mW.
25. DC or dc: Direct current.
26. DCOA: Designated critical operations area.
27. DDC: Direct digital control (HVAC).

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28. EGC: Equipment grounding conductor.
29. ELV: Extra-low voltage.
30. EMF: Electromotive force.
31. EMI: Electromagnetic interference.
32. EPM: Electrical preventive maintenance.
33. EPS: Emergency power supply.
34. EPSS: Emergency power supply system.
35. ESS: Energy storage system.
36. EV: Electric vehicle.
37. EVPE: Electric vehicle power export equipment.
38. EVSE: Electric vehicle supply equipment.
39. fc: Footcandle, an internationally recognized unit of illuminance equal to one lumen per square foot or 10.76 lx. The simplified conversion 1 fc = 10 lx in the Specifications is common practice and considered adequate precision for building construction activities. When there are conflicts, lux is the primary unit; footcandle is specified for convenience.
40. FLC: Full-load current.
41. ft: Foot.
42. ft-cd: Foot-candle, the antiquated U.S. Standard unit of illuminance, equal to one international candle measured at a distance of one foot, that was superseded in 1948 by the unit "footcandle" after the SI unit candela (cd) replaced the international candle; see "fc,"
43. GEC: Grounding electrode conductor.
44. GFCI: Ground-fault circuit interrupter.
45. GFPE: Ground-fault protection of equipment.
46. GND: Ground.
47. HACR: Heating, air conditioning, and refrigeration.
48. HDPE: High-density polyethylene.
49. HP or hp: Horsepower.
50. HVAC: Heating, ventilating, and air conditioning.
51. Hz: Hertz.
52. IBT: Intersystem bonding termination.
53. inch: Inch. To avoid confusion, the abbreviation "in." is not used.
54. IP: Ingress protection rating (enclosures); Internet protocol (communications).
55. IR: Infrared.
56. IS: Intrinsically safe.
57. IT&R: Inspecting, testing, and repair.
58. ITE: Information technology equipment.
59. kAIC: Kiloampere interrupting capacity.
60. kcmil or MCM: One thousand circular mils.
61. kV: Kilovolt.
62. kVA: Kilovolt-ampere.
63. kVAr or kVAR: Kilovolt-ampere reactive.
64. kW: Kilowatt.
65. kWh: Kilowatt-hour.
66. LAN: Local area network.
67. lb: Pound (weight).
68. lbf: Pound (force).
69. LCD: Liquid-crystal display.
70. LCDI: Leakage-current detector-interrupter.
71. LED: Light-emitting diode.
72. Li-ion: Lithium-ion.

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73. lm: Lumen, the SI derived unit of luminous flux.
74. LNG: Liquefied natural gas.
75. LP-Gas: Liquefied petroleum gas.
76. LRC: Locked-rotor current.
77. LV: Low voltage.
78. lx: Lux, the SI derived unit of illuminance equal to one lumen per square meter.
79. m: Meter.
80. MCC: Motor-control center.
81. MDC: Modular data center.
82. MG set: Motor-generator set.
83. MIDI: Musical instrument digital interface.
84. MLO: Main lugs only.
85. MV: Medium voltage.
86. MVA: Megavolt-ampere.
87. mW: Milliwatt.
88. MW: Megawatt.
89. MWh: Megawatt-hour.
90. NC: Normally closed.
91. Ni-Cd: Nickel-cadmium.
92. Ni-MH: Nickel-metal hydride.
93. NIU: Network interface unit.
94. NO: Normally open.
95. NPT: National (American) standard pipe taper.
96. OCPD: Overcurrent protective device.
97. ONT: Optical network terminal.
98. PC: Personal computer.
99. PCS: Power conversion system.
100. PCU: Power-conditioning unit.
101. PF or pf: Power factor.
102. PHEV: Plug-in hybrid electric vehicle.
103. PLC: Programmable logic controller.
104. PLFA: Power-limited fire alarm.
105. PoE: Power over Ethernet.
106. PV: Photovoltaic.
107. PVC: Polyvinyl chloride.
108. pW: Picowatt.
109. RFI: (electrical) Radio-frequency interference; (contract) Request for interpretation.
110. RMS or rms: Root-mean-square.
111. RPM or rpm: Revolutions per minute.
112. SCADA: Supervisory control and data acquisition.
113. SCR: Silicon-controlled rectifier.
114. SPD: Surge protective device.
115. sq.: Square.
116. SWD: Switching duty.
117. TCP/IP: Transmission control protocol/Internet protocol.
118. TEFC: Totally enclosed fan-cooled.
119. TR: Tamper resistant.
120. TVSS: Transient voltage surge suppressor.
121. UL: (standards) Underwriters Laboratories, Inc.; (product categories) UL, LLC.
122. UL CCN: UL Category Control Number.
123. UPS: Uninterruptible power supply.

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124. USB: Universal serial bus.
125. UV: Ultraviolet.
126. V: Volt, unit of electromotive force.
127. V(ac): Volt, alternating current.
128. V(dc): Volt, direct current.
129. VA: Volt-ampere, unit of complex electrical power.
130. VAR: Volt-ampere reactive, unit of reactive electrical power.
131. VFC: Variable-frequency controller.
132. VOM: Volt-ohm-multimeter.
133. VPN: Virtual private network.
134. VRLA: Valve regulated lead acid; also called "sealed lead acid (SLA)" or "valve regulated sealed lead acid."
135. W: Watt, unit of real electrical power.
136. Wh: Watt-hour, unit of electrical energy usage.
137. WPT: Wireless power transfer.
138. WPTE: Wireless power transfer equipment.
139. WR: Weather resistant.

B. Abbreviations and Acronyms for Electrical Raceway Types:

1. CR: Communications raceway.
2. CR-GP: General-purpose communications raceway.
3. CR-P: Plenum communications raceway.
4. CR-R: Riser communications raceway.
5. EMT: Electrical metallic tubing.
6. EMT-A: Aluminum electrical metallic tubing.
7. EMT-S: Steel electrical metallic tubing.
8. ENT: Electrical nonmetallic tubing.
9. EPEC: Electrical HDPE underground conduit (thin wall).
10. EPEC-A: Type A electrical HDPE underground conduit.
11. EPEC-B: Type B electrical HDPE underground conduit.
12. ERMC: Electrical rigid metal conduit.
13. ERMC-A: Aluminum electrical rigid metal conduit.
14. ERMC-S: Steel electrical rigid metal conduit.
15. ERMC-S-G: Galvanized-steel electrical rigid metal conduit.
16. ERMC-S-PVC: PVC-coated-steel electrical rigid metal conduit.
17. FMC: Flexible metal conduit.
18. FMC-A: Aluminum flexible metal conduit.
19. FMC-S: Steel flexible metal conduit.
20. FMT: Steel flexible metallic tubing.
21. FNMC: Flexible nonmetallic conduit. See "LFNC."
22. HDPE: HDPE underground conduit (thick wall).
23. HDPE-40: Schedule 40 HDPE underground conduit.
24. HDPE-80: Schedule 80 HDPE underground conduit.
25. IMC: Steel electrical intermediate metal conduit.
26. LFMC: Liquidtight flexible metal conduit.
27. LFMC-A: Aluminum liquidtight flexible metal conduit.
28. LFMC-S: Steel liquidtight flexible metal conduit.
29. LFMC-SS: Stainless steel liquidtight flexible metal conduit.
30. LFNC: Liquidtight flexible nonmetallic conduit.
31. LFNC-A: Layered (Type A) liquidtight flexible nonmetallic conduit.

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32. LFNC-B: Integral (Type B) liquidtight flexible nonmetallic conduit.
33. LFNC-C: Corrugated (Type C) liquidtight flexible nonmetallic conduit.
34. OFR: Optical fiber raceway.
35. OFR-GP: General-purpose optical fiber raceway.
36. OFR-P: Plenum optical fiber raceway.
37. OFR-R: Riser optical fiber raceway.
38. PVC: Rigid PVC conduit.
39. PVC-40: Schedule 40 rigid PVC conduit.
40. PVC-80: Schedule 80 rigid PVC Conduit.
41. PVC-A: Type A rigid PVC concrete-encased conduit.
42. PVC-EB: Type EB rigid PVC concrete-encased underground conduit.
43. RGS: See ERMC-S-G.
44. RMC: See ERMC.

C. Abbreviations and Acronyms for Electrical Single-Conductor and Multiple-Conductor Cable Types:

1. AC: Armored cable.
2. CATV: Coaxial general-purpose cable.
3. CATVP: Coaxial plenum cable.
4. CATVR: Coaxial riser cable.
5. CI: Circuit integrity cable.
6. CL2: Class 2 cable.
7. CL2P: Class 2 plenum cable.
8. CL2R: Class 2 riser cable.
9. CL2X: Class 2 cable, limited use.
10. CL3: Class 3 cable.
11. CL3P: Class 3 plenum cable.
12. CL3R: Class 3 riser cable.
13. CL3X: Class 3 cable, limited use.
14. CM: Communications general-purpose cable.
15. CMG: Communications general-purpose cable.
16. CMP: Communications plenum cable.
17. CMR: Communications riser cable.
18. CMUC: Under-carpet communications wire and cable.
19. CMX: Communications cable, limited use.
20. DG: Distributed generation cable.
21. FC: Flat cable.
22. FCC: Flat conductor cable.
23. FPL: Power-limited fire-alarm cable.
24. FPLP: Power-limited fire-alarm plenum cable.
25. FPLR: Power-limited fire-alarm riser cable.
26. IGS: Integrated gas spacer cable.
27. ITC: Instrumentation tray cable.
28. ITC-ER: Instrumentation tray cable, exposed run.
29. MC: Metal-clad cable.
30. MC-HL: Metal-clad cable, hazardous location.
31. MI: Mineral-insulated, metal-sheathed cable.
32. MTW: (machine tool wiring) Moisture-, heat-, and oil-resistant thermoplastic cable.
33. MV: Medium-voltage cable.
34. NM: Nonmetallic sheathed cable.

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35. NMC: Nonmetallic sheathed cable with corrosion-resistant nonmetallic jacket.
36. NMS: Nonmetallic sheathed cable with signaling, data, and communications conductors, plus power or control conductors.
37. NPLF: Non-power-limited fire-alarm circuit cable.
38. NPLFP: Non-power-limited fire-alarm circuit cable for environmental air spaces.
39. NPLFR: Non-power-limited fire-alarm circuit riser cable.
40. NUCC: Nonmetallic underground conduit with conductors.
41. OFC: Conductive optical fiber general-purpose cable.
42. OFCG: Conductive optical fiber general-purpose cable.
43. OFCP: Conductive optical fiber plenum cable.
44. OFCR: Conductive optical fiber riser cable.
45. OFN: Nonconductive optical fiber general-purpose cable.
46. OFNG: Nonconductive optical fiber general-purpose cable.
47. OFNP: Nonconductive optical fiber plenum cable.
48. OFNR: Nonconductive optical fiber riser cable.
49. P: Marine shipboard cable.
50. PLTC: Power-limited tray cable.
51. PLTC-ER: Power-limited tray cable, exposed run.
52. PV: Photovoltaic cable.
53. RHH: (high heat) Thermoset rubber, heat-resistant cable.
54. RHW: Thermoset rubber, moisture-resistant cable.
55. SA: Silicone rubber cable.
56. SE: Service-entrance cable.
57. SER: Service-entrance cable, round.
58. SEU: Service-entrance cable, flat.
59. SIS: Thermoset cable for switchboard wiring.
60. TBS: Thermoplastic cable with outer braid.
61. TC: Tray cable.
62. TC-ER: Tray cable, exposed run.
63. TC-ER-HL: Tray cable, exposed run, hazardous location.
64. THW: Thermoplastic, heat- and moisture-resistant cable.
65. THHN: Thermoplastic, heat-resistant cable with nylon jacket outer sheath.
66. THHW: Thermoplastic, heat- and moisture-resistant cable.
67. THWN: Thermoplastic, moisture- and heat-resistant cable with nylon jacket outer sheath.
68. TW: Thermoplastic, moisture-resistant cable.
69. UF: Underground feeder and branch-circuit cable.
70. USE: Underground service-entrance cable.
71. XHH: Cross-linked polyethylene, heat-resistant cable.
72. XHHW: Cross-linked polyethylene, heat- and moisture-resistant cable.

D. Abbreviations and Acronyms for Electrical Flexible Cord Types:

1. SEO: 600 V extra-hard-usage, hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp locations.
2. SEOW: 600 V extra-hard-usage, hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp or wet locations.
3. SEOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp locations.

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4. SEOOW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp or wet locations.
5. SJEO: 300 V hard-usage, junior hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp locations.
6. SJEOW: 300 V hard-usage, junior hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp or wet locations.
7. SJEOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp locations.
8. SJEOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp or wet locations.
9. SJO: 300 V hard-usage, junior hard-service cord with thermoset insulation and oil-resistant thermoset outer cover for damp locations.
10. SJOW: 300 V hard-usage, junior hard-service cord with thermoset insulation and oil-resistant thermoset outer cover for damp or wet locations.
11. SJOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer cover for damp locations.
12. SJOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer cover for damp or wet locations.
13. SJTO: 300 V hard-usage, junior hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer cover for damp locations.
14. SJTOW: 300 V hard-usage, junior hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer cover for damp or wet locations.
15. SJTOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer cover for damp locations.
16. SJTOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer cover for damp or wet locations.
17. SO: 600 V extra-hard-usage, hard-service cord with thermoset insulation and oil-resistant thermoset outer covering for damp locations.
18. SOW: 600 V extra-hard-usage, hard-service cord with thermoset insulation and oil-resistant thermoset outer covering for damp or wet locations.
19. SOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer covering for damp locations.
20. SOOW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer covering for damp or wet locations.
21. STO: 600 V extra-hard-usage, hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer covering for damp locations.
22. STOW: 600 V extra-hard-usage, hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer covering for damp or wet locations.
23. STOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer covering for damp locations.
24. STOOW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer covering for damp or wet locations.

E. Definitions:

1. 8-Position 8-Contact (8P8C) Modular Jack: An unkeyed jack with up to eight contacts commonly used to terminate twisted-pair and multiconductor Ethernet cable. Also called a "TIA-1096 miniature 8-position series jack" (8PSJ), or an "IEC 8877 8-pole jack."

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a. Be careful when suppliers use "RJ45" generically. Obsolete RJ45 jacks used for analog telephone cables have rejection keys. 8P8C jacks used for digital telephone cables and Ethernet cables do not have rejection keys.

2. Basic Impulse Insulation Level (BIL): Reference insulation level expressed in impulse crest voltage with a standard wave not longer than 1.5 times 50 microseconds and 1.5 times 40 microseconds.
3. Cable: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "cable" is (1) a conductor with insulation, or a stranded conductor with or without insulation (single-conductor cable); or (2) a combination of conductors insulated from one another (multiple-conductor cable).
4. Communications Jack: A fixed connecting device designed for insertion of a communications cable plug.
5. Communications Outlet: One or more communications jacks, or cables and plugs, mounted in a box or ring, with a suitable protective cover.
6. Conductor: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "conductor" is (1) a wire or combination of wires not insulated from one another, suitable for carrying an electric current; (2) (National Electrical Safety Code) a material, usually in the form of wire, cable, or bar, suitable for carrying an electric current; or (3) (general) a substance or body that allows a current of electricity to pass continuously along it.
7. Direct Buried: Installed underground without encasement in concrete or other protective material.
8. Enclosure: The case or housing of an apparatus, or the fence or wall(s) surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. Types of enclosures and enclosure covers include the following:

    a. Cabinet: An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.
    b. Concrete Box: A box intended for use in poured concrete.
    c. Conduit Body: A means for providing access to the interior of a conduit or tubing system through one or more removable covers at a junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
    d. Conduit Box: A box having threaded openings or knockouts for conduit, EMT, or fittings.
    e. Cutout Box: An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the enclosure.
    f. Device Box: A box with provisions for mounting a wiring device directly to the box.
    g. Extension Ring: A ring intended to extend the sides of an outlet box or device box to increase the box depth, volume, or both.
    h. Floor Box: A box mounted in the floor intended for use with a floor box cover and other components to complete the floor box enclosure.
    i. Floor-Mounted Enclosure: A floor box and floor box cover assembly with means to mount in the floor that is sealed against the entrance of scrub water at the floor level.

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j. Floor Nozzle: An enclosure used on a wiring system, intended primarily as a housing for a receptacle, provided with a means, such as a collar, for surface-mounting on a floor, which may or may not include a stem to support it above the floor level, and is sealed against the entrance of scrub water at the floor level.
k. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.
l. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.
m. Pedestal Floor Box Cover: A floor box cover that, when installed as intended, provides a means for typically vertical or near-vertical mounting of receptacle outlets above the floor's finished surface.
n. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.
o. Raised-Floor Box: A floor box intended for use in raised floors.
p. Recessed Access Floor Box: A floor box with provisions for mounting wiring devices below the floor surface.
q. Recessed Access Floor Box Cover: A floor box cover with provisions for passage of cords to recessed wiring devices mounted within a recessed floor box.
r. Ring: A sleeve, which is not necessarily round, used for positioning a recessed wiring device flush with the plaster, concrete, drywall, or other wall surface.
s. Ring Cover: A box cover, with raised center portion to accommodate a specific wall or ceiling thickness, for mounting wiring devices or luminaires flush with the surface.
t. Termination Box: An enclosure designed for installation of termination base assemblies consisting of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors, or both.

9. Emergency Systems: Those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction that are designed to ensure continuity of lighting, electrical power, or both, to designated areas and equipment in the event of failure of the normal supply for safety to human life.
10. Essential Electrical Systems: (healthcare facilities) Those systems designed to ensure continuity of electrical power to designated areas and functions of a healthcare facility during disruption of normal power sources, and also to minimize disruption within the internal wiring system.
11. Fault Limited: Providing or being served by a source of electrical power that is limited to not more than 100 W when tested in accordance with UL 62368-1.

    a. The term "fault limited" is intended to encompass most Class 1, 2, and 3 power-limited sources complying with Article 725 of NFPA 70; Class ES1 and ES2 electrical energy sources that are Class PS1 electrical power sources (e.g., USB); and Class ES3 electrical energy sources that are Class PS1 and PS2 electrical power sources (e.g., PoE). See UL 62368-1 for discussion of classes of electrical energy sources and classes of electrical power sources.

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12. High-Performance Building: A building that integrates and optimizes on a life-cycle basis all major high-performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.
13. Jacket: A continuous nonmetallic outer covering for conductors or cables.
14. Luminaire: A complete lighting unit consisting of a light source such as a lamp, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light.
15. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the Energy Independence and Security Act (EISA) of 2007.
16. Multi-Outlet Assembly: A type of surface, flush, or freestanding raceway designed to hold conductors, receptacles, and switches, assembled in the field or at the factory.
17. Plenum: A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.
18. Receptacle: A fixed connecting device arranged for insertion of a power cord plug. Also called a power jack.
19. Receptacle Outlet: One or more receptacles mounted in a box with a suitable protective cover.
20. Sheath: A continuous metallic covering for conductors or cables.
21. UL Category Control Number (CCN): An alphabetic or alphanumeric code used to identify product categories covered by UL's Listing, Classification, and Recognition Services.
22. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:

    a. Control Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is supplied from a battery or other Class 2 or Class 3 power-limited source.
    b. Line Voltage: (1) (controls) Designed to operate using the supplied low-voltage power without transformation. (2) (transmission lines, transformers, SPDs) The line-to-line voltage of the supplying power system.
    c. Extra-Low Voltage (ELV): Not having electromotive force between any two conductors, or between a single conductor and ground, exceeding 30 V(ac rms), 42 V(ac peak), or 60 V(dc).
    d. Low Voltage (LV): Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 30 V but not exceeding 1000 V.

23. Wire: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "wire" is a slender rod or filament of drawn metal. A group of small wires used as a single wire is properly called a "stranded wire." A wire or stranded wire covered with insulation is properly called an "insulated wire" or a "single-conductor cable." Nevertheless, when the context indicates that the wire is insulated, the term "wire" will be understood to include the insulation.

1.3 COORDINATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions:

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1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Construction Manager's written permission.
3. Coordinate interruption with systems impacted by outage including, but not limited to, the following:

    a. Exercising generators.
    b. Emergency lighting.
    c. Elevators.
    d. Fire-alarm systems.

B. Arrange to provide temporary electrical service in accordance with requirements specified in Division 01.

1.4 PREINSTALLATION MEETINGS

A. Electrical Preconstruction Conference: Schedule conference with Architect and Owner, not later than 10 days after notice to proceed. Agenda topics include, but are not limited to, the following:

1. Electrical installation schedule.
2. Status of power system studies.
3. Utility work coordination and class of service requests.
4. Commissioning activities.
5. Sustainability activities, including Measurement and Verification Plan.

1.5 SEQUENCING

A. Conduct and submit results of power system studies before submitting Product Data and Shop Drawings for electrical equipment.

1.6 ACTION SUBMITTALS

A. Coordination drawings.

1.7 INFORMATIONAL SUBMITTALS

A. Electrical installation schedule.

B. Qualification statements.

C. Welding certificates.

D. Delegated design drawings for structural masonry wall penetrations.

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1.8 CLOSEOUT SUBMITTALS

A. Facility EPM program binders.

B. Operation and maintenance data.

C. Software and firmware operational documentation.

D. Software.

1.9 QUALITY ASSURANCE

A. Qualifications: Prepare and submit qualification statements for the following entities performing Work on Project:

1. Qualified Regional Manufacturer: Manufacturer, possessing qualifications specified in Section 014000 "Quality Requirements," that maintains a service center capable of providing training, parts, and emergency on-site repairs to Project site with response time less than eight hours.
2. Structural Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering.
3. Electrical Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in electrical engineering, including electrical power system modeling and analysis of electrical safety in accordance with NFPA 70E.
4. Lighting Professional Engineer: Professional engineer possessing active qualifications in accordance with Section 014000 "Quality Requirements" and the following:

    a. Expertise in electrical engineering, lighting design, and structural requirements for exterior poles and standards.
    b. Lighting Certified (LC) Professional by the National Council on Qualifications for the Lighting Professions (NCQLP).

5. EPM Specialist: Recognized experts possessing the following qualifications in accordance with Section 014000 "Quality Requirements" and NFPA 70B:

    a. Technical Competence: Person should, by education, training, and experience, be well-rounded in all aspects of electrical maintenance.
    b. Administrative and Supervisory Skills: Person should be skilled in planning and development of long-range objectives to achieve specific results and should be able to command respect and solicit cooperation of persons involved in EPM Program development.

6. Welder: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," with training and certification in accordance with AWS D1.1/D1.1M and AWS D1.2/D1.2M.
7. ERMC-S-PVC Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by ERMC-S-PVC manufacturer prior to starting installation.

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8. Electrical Power Monitoring Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by manufacturer prior to starting installation.
9. EVSE Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by EVSE manufacturer prior to starting installation.
10. Generator Set Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by generator set manufacturer prior to starting installation.
11. Lightning Protection System Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired LPI Master Installer credentials prior to starting installation.
12. Low-Voltage Electrical Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

    a. On-site electrical testing supervisors must have documented certification and experience with testing electrical equipment in accordance with NETA testing standards.

13. Power-Limited Electrical Testing Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

    a. On-site power-limited testing supervisor must have BICSI Registered Communications Distribution Designer certification and documented training and experience with testing power-limited equipment in accordance with NETA testing standards.

14. Structural Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing structural concrete.
15. Outdoor Pole Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience in accordance with ASTM C1093 for foundation testing and inspections.
16. Luminaire Photometric Testing Laboratory: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.
17. Lighting Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing and inspecting lighting installations in accordance with IES LM-5.

B. Certifications:

1.10 FIELD CONDITIONS

A. Modeling, analysis, product selection, installation, and quality control for Work specified in Division 26 must comply with requirements specified in Section 260011 "Facility Performance Requirements for Electrical."

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PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 PREPARATION

A. Electrical Installation Schedule: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for electrical installation Work to Owner and Architect including, but not limited to, milestone dates for the following activities:

1. Submission of power system studies.
2. Submission of specified coordination drawings.
3. Submission of action submittals specified in Division 26.
4. Orders placed for major electrical equipment.
5. Arrival of major electrical equipment on-site.
6. Preinstallation meetings specified in Division 26.
7. Utility service outages.
8. Utility service inspection and activation.
9. Mockup reviews.
10. Closing of walls and ceilings containing electrical Work.
11. System startup, testing, and commissioning activities for major electrical equipment.
12. System startup, testing, and commissioning activities for emergency lighting.
13. System startup, testing, and commissioning activities for automation systems (SCADA, BMS, lighting, HVAC, fire alarm, fire pump, etc.).
14. Pouring of concrete housekeeping pads for electrical equipment and testing of concrete samples.
15. Requests for special inspections.
16. Requests for inspections by authorities having jurisdiction.

B. Coordination Drawings for Structural Supports: Show coordination of structural supports for equipment and devices, with other systems, equipment, and structural supports in the vicinity.

C. Coordination Drawings for Ceiling Areas: Where indicated on Drawings, provide reflected ceiling plan(s), supplemented by sections and other details, drawn to scale, in accordance with Section 013100 "Project Management and Coordination," on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which equipment, luminaires, and suspension systems will be attached.
3. Partitions and millwork that penetrate ceiling or extend to within 12 inch of plane of luminaires.
4. Size and location of access panels on ceilings.
5. Elevation, size, and route of sprinkler piping.
6. Elevation, size, and route of plumbing piping.
7. Elevation, size, and route of ductwork.
8. Elevation, size, and route of cable tray.
9. Elevation, size, and route of conduit.
10. Elevation and size of wall-mounted and ceiling-mounted equipment.

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11. Moldings.
12. Access panels.
13. Sprinklers.
14. Air inlets and outlets.
15. Control modules.
16. Luminaires.
17. Communications devices.
18. Speakers.
19. Ceiling-mounted projectors.
20. Security devices.
21. Fire-alarm devices.
22. Indicate clear dimensions for maintenance access in front of equipment.
23. Indicate dimensions of fully-open access doors.

D. Coordination Drawings for Cable Tray Routing: Reflected ceiling plan(s), supplemented by sections and other details, drawn to scale, in accordance with Section 013100 "Project Management and Coordination," on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Elevation, size, and route of cable trays.
2. Relationships between components and adjacent structural, electrical, and mechanical elements.
3. Vertical and horizontal offsets and transitions.
4. Elevation and size of sleeves for wall, ceiling, and floor cable penetrations.
5. Elevation of ceilings and size of ceiling tiles.
6. Locations of access panels on ceilings.
7. Locations where cable tray crosses or parallels sprinkler piping.
8. Locations where cable tray crosses plumbing piping.
9. Locations where cable tray crosses or parallels ductwork.
10. Locations of access panels on ductwork.
11. Locations where cable tray crosses conduit.
12. Items blocking access around cable trays, including the following:

    a. Light fixtures.
    b. Speakers.
    c. Fire-alarm devices.
    d. Power outlets.
    e. Wall-mounted equipment.
    f. Equipment racks.
    g. Furniture.
    h. Door swings.
    i. Building features.

13. Indicate clear dimension between cable tray and walls or obstructions that are closer than 10 ft.
14. Highlight locations where cable tray is greater than 3 ft above ceilings. Explain how personnel access will be accommodated for cable tray maintenance.

E. Coordination Drawings for Conduit Routing: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

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1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

F. Coordination Drawings for Large Equipment Indoor Installations:

1. Location plan, drawn to scale, showing heavy equipment or truck access paths to loading dock or other freight access into building. Indicate available width and height of doors or openings.
2. Floor plan for entry floor and floor where equipment is located, drawn to scale, showing heavy equipment access paths for maintenance and replacement, with the following items shown and coordinated with each other, based on input from installers of the items involved:

    a. Dimensioned concrete bases, outlines of equipment, conduit entries, and grounding equipment locations.
    b. If freight elevator must be used, indicate width and height of door and depth of car. Indicate if large equipment must be tipped to use elevator.
    c. Dimensioned working clearances and dedicated areas below and around electrical equipment where obstructions and tripping hazards are prohibited.

3. Reflected ceiling plans for entry floor and floor where equipment is located, drawn to scale, on which the following items shown and coordinated with each other, based on input from installers of the items involved:

    a. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways.
    b. Location of lighting fixtures, sprinkler piping and sprinklers, ducts and diffusers, and other obstructions, indicating available overhead clearance.
    c. Dimensioned working clearances and dedicated areas above and around electrical equipment where foreign systems and equipment are prohibited.

G. Coordination Drawings for Large Equipment Outdoor Installations:

1. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement, with the following items shown and coordinated with each other, based on input from installers of the items involved:

    a. Fences and walls, dimensioned concrete bases, outlines of equipment, conduit entries, and grounding and bonding locations.
    b. Indicate clear dimensions for fence gates and wall openings.
    c. Indicate depth and type of ground cover, and locations of trees, shrubbery, and other obstructions in access path.
    d. Indicate clear height below tree branches, overhead lines, bridges, and other overhead obstructions in access path, or where cranes and hoists will be needed to handle large electrical equipment.
    e. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways.
    f. Dimensioned working clearances and dedicated areas around electrical equipment.

H. Coordination Drawings for Duct Banks:

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1. Show duct profiles and coordination with other utilities and underground structures.
2. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.

3.2 INSTALLATION OF ELECTRICAL WORK

A. Unless more stringent requirements are specified in the Contract Documents or manufacturers' written instructions, comply with NFPA 70 and NECA NEIS 1 for installation of Work specified in Division 26. Consult Architect for resolution of conflicting requirements.

3.3 SYSTEM STARTUP

A. Commissioning Activities:

3.4 FIELD QUALITY CONTROL

A. Administrant for Low-Voltage Electrical Tests and Inspections:

1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

B. Administrant for Structural Tests and Inspections:

1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

C. Administrant for Field Tests and Inspections of Lighting Installations:

1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

3.5 CLOSEOUT ACTIVITIES

A. Development of Facility EPM Program

1. Facility EPM Program must be developed by qualified EPM specialist.
2. Conduct Facility EPM Program analysis in accordance with NFPA 70B recommendations.

3. Compile operation and maintenance data from Facility EPM Program analysis and submit updated Facility EPM Program Binders.
4. Organization of Facility EPM Program Binders:

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a. Description: Set of binders containing operation and maintenance data for facility's electrical equipment that was compiled during analysis of installed electrical Work for Facility EPM Program development.
b. Referenced Standards: Content must comply with recommendations in NFPA 70B.
c. General Characteristics:

1) Volume 1 - Introduction:

a) Summarize how Facility EPM Program Analysis was performed, how data were collected, and how volumes are organized.
b) Describe Facility EPM Program and provide recommended policies and procedures for implementing the program and keeping it current.
c) Provide place for Owner to identify contact information for employees responsible for implementing and maintaining Facility EPM Program.

2) Volume 2 - Facility Safety, Hazards Awareness, and Emergency Procedures:

a) Include training requirements for employees and contractors.
b) Include list of known facility hazards impacting IT&R activities.
c) Include approval and permitting procedures for IT&R activities.
d) Include incident emergency response procedures.
e) Include emergency shutdown procedures.
f) Include electrical disaster recovery procedures.

3) Volume 3 - Operating Procedures for Electrical Equipment and Controls:

a) Include copies of demonstration and training videos.

4) Volume 4 - Facility Diagrams and Schedules:

a) Include single-line diagrams.
b) Include grounding and bonding diagrams.
c) Include essential wiring diagrams.
d) Include system communications diagrams (WAN, LAN, Wi-Fi, ERCES, MNS, etc.)
e) Include system automation diagrams (SCADA, BMS, lighting, HVAC, etc.).
f) Include records of switchboard and panelboard schedules.
g) Include time-current curves for overcurrent protective devices.
h) Include list of load-current and overload-relay heaters with related motor nameplate data.

5) Volume 5 - Inventory of Facility Equipment Using Electrical Power:

a) Include simplified floor plans showing equipment locations.
b) Identify critical equipment (electrical or otherwise).
c) Include identifying designations and nameplate data.
d) Include warranty and maintenance contract information.

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6) Volume 6 - Inventory of Facility Tools, Supplies, and Personnel Protective Equipment:

a) Include schedules of maintenance material items recommended to be stored at facility.
b) Include list of lamp types and photoelectric relays used in facility with ANSI and manufacturers' codes.
c) Include calibration and servicing data for each item.

7) Volume 7 - Inspection, Testing, and Repair (IT&R) Plan:

a) Include tables showing frequency of activities for each item.
b) Include annual schedule with activities mapped to specific days of the year.
c) Include exterior pole inspection and repair procedures.

8) Volume 8 - Inspection, Testing, and Repair (IT&R) Forms:

9) Volume 9 - Inspection, Testing, and Repair (IT&R) Procedures:

10) Volume 10 - Spare Parts List:

a) Include list of all parts required to perform IT&R procedures.
b) Identify quantities of which parts are recommended to be stored on-site.
c) Include source contact information and budget cost for each item.

11) Volume 11 - Construction Project Closeout Record Documentation:

a) Include records of power system studies and photometric studies.
b) Include records of risk assessment studies.
c) Include records of electrical system startup and commissioning activities.
d) Include records of baseline inspections and tests.
e) Include records of baseline infrared photographs with normal light photographs showing the location, direction, angle, and conditions necessary for reproducing each infrared photograph.
f) Include records of baseline settings for adjustable equipment and devices.

5. Format of Facility EPM Program Binders Submittal:

a. Complete Set: On approved online or cloud solution and USB media that is clearly and permanently labeled with attached placard on lanyard to prevent misplacement.
b. Volumes 2 and 8: Reproducible hardcopy on archival quality, 28 lb, acid-free, bond paper.

B. Operation and Maintenance Data: Prepare and submit the following:

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1. Provide emergency operation, normal operation, and preventive maintenance manuals for each system, equipment, and device listed below:

2. Include the following information:

   a. Manufacturer's operating specifications.
   b. User's guides for software and hardware.
   c. Schedule of maintenance material items recommended to be stored at Project site.
   d. Detailed instructions covering operation under both normal and abnormal conditions.
   e. Time-current curves for overcurrent protective devices and manufacturer's written instructions for testing and adjusting their settings.
   f. List of load-current and overload-relay heaters with related motor nameplate data.
   g. List of lamp types and photoelectric relays used on Project, with ANSI and manufacturers' codes.
   h. Manufacturer's instructions for setting field-adjustable components.
   i. Manufacturer's instructions for testing, adjusting, and reprogramming microprocessor controls.
   j. EPSS: Manufacturer's system checklists, maintenance schedule, and maintenance log sheets in accordance with NFPA 110.
   k. Exterior pole inspection and repair procedures.
   l. Include copies of demonstration and training videos.

C. Software and Firmware Operational Documentation: Provide software and firmware operational documentation in Facility EPM Program Binders, including the following:

1. Software operating and upgrade manuals.
2. Names, versions, and website addresses for locations of installed software.
3. Device address list.
4. Printout of software application and graphic screens.
5. Testing and adjusting of panic and emergency power features.
6. For lighting controls, include the following:

   a. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
   b. Operation of adjustable zone controls.

D. Software:

1. Program Software Backup: Provide username and password for approved online or cloud solution and USB media that is clearly and permanently labeled with attached placard on lanyard to prevent misplacement.
2. Provide to Owner upgrades and unrestricted licenses for installed and backup software, including operating systems and programming tools required for operation and maintenance.

E. Demonstration: With assistance from factory-authorized service representatives, demonstrate to Owner's maintenance and clerical personnel and building occupants how to operate the following systems and equipment:

1. Lighting control devices specified in Section 260923 "Lighting Control Devices."

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F. Training: With assistance from factory-authorized service representatives, train Owner's maintenance personnel on the following topics:

1. How to implement updated Facility EPM Program.
2. How to adjust, operate, and maintain equipment specified in Section 111136 "Vehicle Charging Equipment."
3. How to operate normal and emergency electrical systems, including justifications for, and limitations of, protective device settings recommended in study report specified in Section 260573.16 "Coordination Studies."
4. Electrical power safety fundamentals refresher including arc-flash hazard safety features of electrical power distribution equipment in facility, interpreting arc-flash warning labels, selecting appropriate personal protective equipment, and understanding significance of findings documented in study report specified in Section 260573.19 "Arc-Flash Hazard Analysis."
5. How to adjust, operate, and maintain systems specified in Section 260913 "Electrical Power Monitoring."
6. How to adjust, operate, and maintain devices specified in Section 260923 "Lighting Control Devices."
7. How to adjust, operate, and maintain hardware and software specified in Section 260936 "Modular Dimming Controls." Laptop computer must be used in training.
8. How to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units specified in Section 262413 "Switchboards."
9. How to adjust, operate, and maintain hardware and software specified in Section 262713 "Electricity Metering."
10. How to adjust, operate, and maintain equipment specified in Section 262913.03 "Manual and Magnetic Motor Controllers."
11. How to adjust, operate, and maintain equipment specified in Section 262913.06 "Soft-Start Motor Controllers."
12. How to adjust, operate, and maintain equipment specified in Section 263213.13 "Diesel-Engine-Driven Generator Sets."
13. How to adjust, operate, and maintain transfer switches and related equipment, including ground-fault protection system, specified in Section 263600 "Transfer Switches."
14. How to adjust, operate, and maintain devices specified in Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits."
15. How to adjust, operate, and maintain luminaires and photoelectric controls specified in Section 265000 "Lighting."

END OF SECTION 26 00 10

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SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper building wire.
2. Aluminum conductors, used for feeders #2 AWG and larger.
3. Metal-clad cable, Type HCF-90 Health Care Facilities.
4. Mineral-insulated cable, Type MI.
5. Fire-alarm wire and cable.
6. Connectors and splices.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Copper building wire.
2. Aluminum conductors, used for feeders #2 AWG and larger.
3. Metal-clad cable, Type HCF-90 Health Care Facilities.
4. Mineral-insulated cable, Type MI.
5. Fire-alarm wire and cable.
6. Connectors and splices.

B. Product Schedule: Indicate type, use, location, and termination locations.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cerro Wire LLC.

2. Encore Wire Corporation.
3. General Cable; Prysmian Group North America.
4. Southwire Company, LLC.

B. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

E. Conductor Insulation:

1. Type THHN. Comply with UL 83.
2. Type UF. Comply with UL 83 and UL 493.

2.2 ALUMINUM CONDUCTORS, USED FOR FEEDERS #2 AWG AND LARGER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Encore Wire Corporation.
2. General Cable; Prysmian Group North America.
3. Southwire Company, LLC.

B. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Aluminum, complying with ASTM B800 and ASTM B801.

E. Conductor Insulation:

1. Type THHN and Type THWN-2. Comply with UL 83.

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2.3 METAL-CLAD CABLE, TYPE HCF-90 HEALTH CARE FACILITIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems; Atkore International.
2. Encore Wire Corporation.
3. General Cable; Prysmian Group North America.
4. Southwire Company, LLC.

B. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Circuits:

1. Single circuit.
2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

E. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

F. Ground Conductor: Insulated.

G. Conductor Insulation:

1. Type THHN/THWN-2. Comply with UL 83.

H. Armor: Steel, interlocked.

I. Jacket: PVC applied over armor.

2.4 MINERAL-INSULATED CABLE, TYPE MI

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. KME America, Inc.
2. PYROTENAX; brand of nVent Electrical plc.
3. Watlow Electric Manufacturing Company.

B. Description: Solid copper conductors encased in compressed metal oxide with an outer metallic sheath, rated 600 V or less.

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C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. UL 2196 for fire resistance.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper.

E. Insulation: Compressed magnesium oxide.

F. Sheath: Copper.

2.5 FIRE-ALARM WIRE AND CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Allied Wire & Cable Inc.
2. PYROTENAX; brand of nVent Electrical plc.
3. West Penn Wire; brand of Belden, Inc.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG or size as recommended by system manufacturer.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.6 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M Electrical Products.
2. ABB, Electrification Business.

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3. AFC Cable Systems; Atkore International.
4. Hubbell Utility Solutions; Hubbell Incorporated.
5. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
6. Service Wire Co.

B. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

1. Material: Copper.
2. Type: One hole with standard barrels.
3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders:

1. Copper for feeders smaller than No. 2 AWG; copper or aluminum for feeders No. 2 AWG and larger. Conductors must be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits:

1. Copper:

a. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. ASD Output Circuits Cable: Extra-flexible stranded for all sizes.

D. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

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D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway or Metal-clad cable, Type HCF-90 Health Care Facilities.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

3.3 INSTALLATION, GENERAL

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points in accordance with Section 260533.13 "Conduits for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.4 INSTALLATION OF FIRE-ALARM WIRE AND CABLE

A. Comply with NFPA 72.

B. Wiring Method: Install wiring in metal pathway according to Section 270528.29 "Hangers and Supports for Communications Systems."

1. Install plenum cable in environmental airspaces, including plenum ceilings.
2. Fire-alarm circuits and equipment control wiring associated with fire-alarm system must be installed in a dedicated pathway system.

    a. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.

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3. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and CI, is permitted.
4. Signaling Line Circuits: Power-limited fire-alarm cables must not be installed in the same cable or pathway as signaling line circuits.

C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes; cabinets; or equipment enclosures where circuit connections are made.

E. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire-alarm system junction boxes and covers red.

F. Risers: Install at least two vertical cable risers to serve the fire-alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent receipt or transmission of signals from other floors or zones.

G. Wiring to Remote Alarm Transmitting Device: 1 inch conduit between the fire-alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.5 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inch of slack.

D. Comply with requirements in Section 284621.11 "Addressable Fire-Alarm Systems" for connecting, terminating, and identifying wires and cables.

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3.6 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.8 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors and conductors feeding the following critical equipment and services for compliance with requirements:

   a. All generators.
   b. All switchboards.
   c. All transfer switches.
   d. All distribution type panelboards.
   e. All branch circuit panelboards.

2. Perform each of the following visual and electrical tests:

   a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
   b. Test bolted connections for high resistance using one of the following:

      1) A low-resistance ohmmeter.
      2) Calibrated torque wrench.
      3) Thermographic survey.

   c. Inspect compression-applied connectors for correct cable match and indentation.
   d. Inspect for correct identification.
   e. Inspect cable jacket and condition.

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f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.
g. Continuity test on each conductor and cable.
h. Uniform resistance of parallel conductors.

3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 26 05 19

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SECTION 26 05 23

CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Control cable.
2. Control-circuit conductors.
3. Fire-alarm wire and cable.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Control cable.
2. Control-circuit conductors.
3. Fire-alarm wire and cable.

1.3 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

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1. Flame Travel Distance: 60 inch or less.
2. Peak Optical Smoke Density: 0.5 or less.
3. Average Optical Smoke Density: 0.15 or less.

C. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

D. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.2 CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.

1. Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.3 CONTROL-CIRCUIT CONDUCTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Encore Wire Corporation.
2. General Cable; Prysmian Group North America.
3. Service Wire Co.
4. Southwire Company, LLC.

B. Class 1 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

C. Class 2 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

D. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

E. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.

NOT FOR BIDDING PURPOSES

1. Smoke control signaling and control circuits.

2.4 FIRE-ALARM WIRE AND CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Allied Wire & Cable Inc.
2. CommScope, Inc.
3. Comtran Corporation.
4. Genesis Cable Products; Honeywell International, Inc.
5. Prysmian Cables and Systems; Prysmian Group North America.
6. Radix Wire.
7. Rockbestos-Suprenant Cable Corp.
8. Superior Essex Inc.; subsidiary of LS Corp.
9. West Penn Wire; brand of Belden, Inc.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG or size as recommended by system manufacturer.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Control-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Low-Voltage Circuits: No. 12 AWG, minimum, in pathway.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire-alarm installation, plenum rated.

2.5 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test twisted pair cables according to TIA-568-C.2.

C. Cable will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Test cables on receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

3.2 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" for raceway selection and installation requirements for conduits as supplemented or modified in this Section.

B. Comply with requirements in Section 260533.16 "Boxes and Covers for Electrical Systems" for raceway selection and installation requirements for boxes as supplemented or modified in this Section.

1. Outlet boxes must be no smaller than 2 inch wide, 3 inch high, and 2-1/2 inch deep.
2. Outlet boxes for cables must be no smaller than 4 inch square by 2-1/8 inch deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
3. Flexible metal conduit must not be used.

C. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.

D. Install manufactured conduit sweeps and long-radius elbows if possible.

E. Raceway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
2. Secure conduits to backboard if entering the room from overhead.
3. Extend conduits 6 inch above finished floor or as noted on drawings.
4. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

F. Backboards: Install backboards with 96 inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."

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3. Terminate all conductors; cable must not contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and must be continuous from terminal to terminal. Do not splice cable between termination, tap, or junction points.
5. Cables serving a common system may be grouped in a common raceway. Install network cabling and control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inch and not more than 6 inch from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals. Do not bend cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
15. Ground wire must be copper, and grounding methods must comply with IEEE C2. Demonstrate ground resistance.

C. Installation of Control-Circuit Conductors:

1. Install wiring in raceways.
2. Use insulated spade lugs for wire and cable connection to screw terminals.

D. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inch above ceilings by cable supports not more than 30 inch apart.
3. Cable must not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

E. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment must be as follows:

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a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 5 inch.
b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 12 inch.
c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 24 inch.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment must be as follows:

a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inch.
b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inch.
c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inch.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures must be as follows:

a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inch.
c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inch.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inch.

3.4 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits; No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.6 GROUNDING

A. For control-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

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3.7 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify data and communications system components, wiring, and cabling according to TIA-606-B; label printers must use label stocks, laminating adhesives, and inks complying with UL 969.

C. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire must have a unique tag.

3.8 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.

    a. Test instruments must meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 26 05 23

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SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grounding and bonding conductors.
2. Grounding and bonding clamps.
3. Grounding and bonding bushings.
4. Grounding and bonding hubs.
5. Grounding and bonding connectors.
6. Intersystem bonding bridge grounding connector.
7. Grounding and bonding busbars.
8. Signal reference grids.
9. Grounding (earthing) electrodes.
10. Grounding electrode enclosures.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" specifies additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 264113 "Lightning Protection for Structures" specifies bonding of lightning protection grounding electrodes to facility grounding electrodes.
3. Section 271100 "Communications Equipment Room Fittings" specifies additional requirements for grounding and bonding of communications equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Plans showing dimensioned locations of grounding features described in "Field Quality Control for Grounding and Bonding of Electrical Power" Article, including the following:

1. Grounding electrode access enclosures.
2. Grounding electrodes.
3. Grounding arrangements and connections for separately derived systems.

C. Field quality-control reports.

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1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. In addition to items specified in Section 260010 "Supplemental Requirements for Electrical," include the following:

a. Plans showing locations of grounding features described in "Field Quality Control for Grounding and Bonding of Electrical Power" Article, including the following:

1) Grounding electrode access enclosures.
2) Grounding electrodes.
3) Grounding arrangements and connections for separately derived systems.

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

A. Equipment Grounding Conductor:

1. General Characteristics: 600 V, THHN/THWN-2 or THWN-2, copper wire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Isolated Equipment Grounding Conductor:

1. General Characteristics: 600 V, THHN/THWN-2 or THWN-2, copper wire or cable, green color with one or more yellow stripes, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. ASTM - Bare Copper Grounding and Bonding Conductor:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ERICO; brand of nVent Electrical plc.
b. Harger Lightning & Grounding; business of Harger, Inc.

2. Referenced Standards: Complying with one or more of the following:

a. Soft or Annealed Copper Wire: ASTM B3.
b. Concentric-Lay Stranded Copper Conductor: ASTM B8.
c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.
d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.

D. UL KDER - Armored Grounding Wire:

1. Description: Single corrosion-resistant copper, aluminum, or copper-clad aluminum conductor within helically formed steel armor.

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2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. LS Cable & System USA; subsidiary of LS Corp.
   b. Southwire Company, LLC.
   c. Superior Essex Inc.; subsidiary of LS Corp.
   d. Viakon; brand of Conductores Monterrey S.A. de C.V.; a subsidiary of Xignux.

3. Regulatory Requirements:

   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

4. Listing Criteria:

   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

E. UL KDSH - Protector Grounding Conductor:

1. Description: Conductors intended to be used for grounding primary protector or metallic members of cable sheath in accordance with Chapters 7 and 8 of NFPA 70.
2. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Superior Essex Inc.; subsidiary of LS Corp.

3. Regulatory Requirements:

   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

4. Listing Criteria:

   a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

5. Options:

   a. Color: Light olive gray or green.

2.2 GROUNDING AND BONDING CLAMPS

A. Description: Clamps suitable for attachment of grounding and bonding conductors to grounding electrodes, pipes, tubing, and rebar. Grounding and bonding clamps specified in this article are also suitable for use with communications applications.

B. Source Limitations: Obtain products from single manufacturer.

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C. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Listing Criteria:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

D. UL KDER and KDSH - Hex-Fitting-Type Pipe and Rod Grounding and Bonding Clamp:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. ERICO; brand of nVent Electrical plc.
e. Panduit Corp.
f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
g. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics:

a. Two pieces with zinc-plated bolts.
b. Clamp Material: Die-cast zinc alloy.
c. Listed for outdoor use.

E. UL KDER and KDSH - U-Bolt-Type Pipe and Rod Grounding and Bonding Clamp:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. ERICO; brand of nVent Electrical plc.
e. Panduit Corp.
f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics:

a. Clamp Material: Tinned brass.
b. Listed for outdoor use.

F. UL KDER and KDSH - Strap-Type Pipe and Rod Grounding and Bonding Clamp:

NOT FOR BIDDING PURPOSES

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    b. Crouse-Hinds; brand of Eaton, Electrical Sector.
    c. ERICO; brand of nVent Electrical plc.
    d. Panduit Corp.

2. General Characteristics:

    a. Clamp Material: Galvanized steel.
    b. Listed for outdoor use.

G. UL KDER - Beam Grounding and Bonding Clamp:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Panduit Corp.
    c. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Mechanical-type, terminal, ground wire access from four directions; with dual, tin-plated or silicon bronze bolts.

H. UL KDER - Exothermically Welded Connection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Crouse-Hinds; brand of Eaton, Electrical Sector.
    c. ERICO; brand of nVent Electrical plc.
    d. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING AND BONDING BUSHINGS

A. Description: Bonding bushings connect conduit fittings, tubing fittings, threaded metal conduit, and unthreaded metal conduit to metal boxes and equipment enclosures and have one or more bonding screws intended to provide electrical continuity between bushing and enclosure. Grounding bushings have provision for connection of bonding or grounding conductor and may or may not also have bonding screws.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:

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1. Regulatory Requirements:

    a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. Listing Criteria:

    a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

D. UL KDER - Bonding Bushing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Crouse-Hinds; brand of Eaton, Electrical Sector.
    c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Threaded bushing with insulated throat.

E. UL KDER - Grounding Bushing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Crouse-Hinds; brand of Eaton, Electrical Sector.
    c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Threaded bushing with insulated throat and mechanical-type wire terminal.

2.4 GROUNDING AND BONDING HUBS

A. Description: Hubs with certified grounding or bonding locknut.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:

1. Regulatory Requirements:

    a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. Listing Criteria:

    a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

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D. UL KDER - Grounding and Bonding Hub:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.

2. General Characteristics: Insulated, gasketed, watertight hub with mechanical-type wire terminal.

2.5 GROUNDING AND BONDING CONNECTORS

A. Source Limitations: Obtain products from single manufacturer.

B. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. Listing Criteria:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

C. UL KDER - Pressure-Type Grounding and Bonding Busbar Cable Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Copper or copper alloy, for compression bonding of one or more conductor directly to copper busbar. Listed for direct burial.

D. UL KDER - Lay-In Lug Mechanical-Type Grounding and Bonding Busbar Terminal:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

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2. General Characteristics: Mechanical-type, copper rated for direct burial terminal with set screw.

E. UL KDER - Crimped Lug Pressure-Type Grounding and Bonding Busbar Terminal:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Cast silicon bronze, solderless compression-type wire terminals; with long barrel and two holes spaced on 5/8 or 1 inch centers for two-bolt connection to busbar.

F. UL KDER - Split-Bolt Service-Post Pressure-Type Grounding and Bonding Busbar Terminal:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Panduit Corp.
b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Bolts that surround cable and bond to cable under compression when nut is tightened after assembly is screwed into busbar opening.

G. UL KDER - Crimped Pressure-Type Grounding and Bonding Cable Connector>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Crimp-and-compress connectors that bond to conductor when connector is compressed around conductor.

a. Copper, C and H shaped.

H. UL KDER - Split-Bolt Pressure-Type Grounding and Bonding Cable Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. ERICO; brand of nVent Electrical plc.
c. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Bolts that surround cable and bond to cable under compression when nut is tightened.

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a. Copper.

I. UL KDER - Signal Reference Grid Grounding and Bonding Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. ERICO; brand of nVent Electrical plc.
d. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.

2.6 INTERSYSTEM BONDING BRIDGE GROUNDING CONNECTORS

A. Description: Devices that provide means for connecting communications systems grounding and bonding conductors at service equipment or at disconnecting means for buildings or structures.

B. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. Listing Criteria:

a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

C. UL KDSH - One-Piece Intersystem Bonding Bridge Grounding Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Galvan Industries, Inc.; Electrical Products Division, LLC.
b. Madison Electric Products; business of Southwire Company, LLC.

2. General Characteristics: Zinc-alloy one-piece construction; six terminating points; gangable.

D. UL KDSH - Two-Piece Intersystem Bonding Bridge Grounding Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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a. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Copper body and polycarbonate cover; four terminating points.

2.7 GROUNDING AND BONDING BUSBARS

A. Description: Miscellaneous grounding and bonding devices that serve as common connection for multiple grounding and bonding conductors.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. Listing Criteria:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

D. UL KDER - Equipment Room Grounding and Bonding Busbar:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Cooper B-line; brand of Eaton, Electrical Sector.
b. ERICO; brand of nVent Electrical plc.
c. Hoffman; brand of nVent Electrical plc.
d. Panduit Corp.
e. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics:

a. Bus: Rectangular bar of annealed copper.
b. Mounting Stand-Off Insulators: Lexan or PVC.

1) Comply with UL 891 for use in 600 V switchboards, impulse tested at 5000 V.

3. Options:

a. Dimensions: 1/4 by 4 inch in cross section; length as indicated on Drawings.
b. Predrilled Hole Pattern: Suitable for installing specified grounding and bonding connectors.

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c. Mounting Hardware: Stand-off brackets that provide 4 inch clearance to access rear of bus. Brackets and bolts must be stainless steel.

E. UL KDER - Rack and Cabinet Bonding Busbar:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Cooper B-line; brand of Eaton, Electrical Sector.
b. Hoffman; brand of nVent Electrical plc.
c. Panduit Corp.

2. General Characteristics:

a. Bus: Rectangular bar of hard-drawn solid copper.
b. Horizontal Mounting Dimensions: Designed for mounting in 23 inch wide equipment racks or cabinets.
c. Vertical Mounting Dimensions: Designed for mounting in 72 inch high equipment racks or cabinets.
d. Predrilled Hole Pattern: Accepts connectors for grounding and bonding conductor sizes 14 AWG to 2/0 AWG.
e. Mounting Hardware: Stainless steel or copper-plated, for attachment to rack.

2.8 SIGNAL REFERENCE GRIDS

A. Description: Means for providing low-impedance path to ground over a large area, approximating an equipotential plan, while simultaneously mitigating large current spikes from faults or lightning.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. Listing Criteria:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

D. UL KDER - Mesh-Type Signal Reference Grid <Insert drawing designation>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
b. Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated.

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c. Harger Lightning & Grounding; business of Harger, Inc.

2. General Characteristics: Conductive metal wire mesh for field-fabrication of grid.

a. Wire Size: 8 AWG.
b. Wire Material: Copper.
c. Spacing: 4 inch.
d. Welded or brazed intersections.

E. UL KDER - Tape-Type Signal Reference Grid:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated.
b. ERICO; brand of nVent Electrical plc.
c. Harger Lightning & Grounding; business of Harger, Inc.

2. General Characteristics: Conductive copper tape for field-fabrication of grid.

a. Copper Tape Dimensions: 16 mil (26 ga.) thick by 2 inch wide.
b. Spacing: 24 inch.
c. Welded or brazed fittings for intersections.

2.9 GROUNDING (EARTHING) ELECTRODES

A. Source Limitations: Obtain products from single manufacturer.

B. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. Listing Criteria:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

C. UL KDER - Rod Electrode:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. ERICO; brand of nVent Electrical plc.

2. General Characteristics: Copper-clad steel, sectional type; 3/4 inch by 10 ft.

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D. UL KDER - Plate Electrode:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ALLTEC LLC.
b. Galvan Industries, Inc.; Electrical Products Division, LLC.

2. General Characteristics: 1/4 inch thick, hot-dip galvanized.

2.10 GROUNDING ELECTRODE ENCLOSURES

A. Description: Enclosures designed to protect grounding electrodes from damage while providing access for inspection and testing of the grounding system.

B. Grounding Electrode Access Well Enclosure:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ERICO; brand of nVent Electrical plc.
b. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.

2. Source Limitations: Obtain products from single manufacturer.
3. Product Characteristics:

a. Well Material: Schedule 40 PVC.
b. Cover Material: Plastic.
c. Cover Strength: Driveway use.

4. Required Product Options:

a. Rectangular:

1) Nominal Width: As required.
2) Nominal Length: As required.
3) Nominal Height: As required.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.

B. Inspect test results of grounding system measured at point of electrical service equipment connection.

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C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF GROUNDING AND BONDING PRODUCTS

A. Grounding and Bonding Conductors:

1. Provide solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.
2. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.
3. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, 1/4 inch in diameter.
4. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.
5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
6. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
7. Underground Grounding Conductors: Install bare tinned-copper conductor, 2/0 AWG minimum.

B. Grounding and Bonding Connectors:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

C. Grounding and Bonding Busbars: Provide in rooms as indicated on Drawings.

3.3 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR COMMUNICATIONS

A. Comply with Section 270528 "Pathways for Communications Systems" and Section 271100 "Communications Equipment Room Fittings."

3.4 INSTALLATION OF GROUNDING AND BONDING

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.

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2. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. Grounding and Bonding Conductors:

a. Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
b. Underground Grounding Conductors:

1) Bury at least 30 inch below grade.

2. Grounding and Bonding Connectors: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
b. Make connections with clean, bare metal at points of contact.
c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
f. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1) Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate adjacent parts.
2) Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3) Use exothermic-welded connectors for outdoor locations; if disconnect-type connection is required, use bolted clamp.

g. Grounding and Bonding for Piping:

1) Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2) Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with bolted connector.
3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

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h. Grounding for Steel Building Structure: Install driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft apart.

3. Grounding and Bonding Busbars:

a. Install busbar horizontally, on insulated spacers 2 inch minimum from wall, 6 inch above finished floor unless otherwise indicated.
b. Where busbars are indicated on both sides of doorways, route bonding conductor up to top of door frame, across top of doorway, and down; connect to continuation of horizontal busbar.

4. Electrodes:

a. Ground Rods: Drive rods until tops are 2 inch below finished floor or final grade unless otherwise indicated.

1) Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2) Use exothermic welds for below-grade connections.

b. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least same distance from other grounding electrodes, and connect to service grounding electrode conductor.
c. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and must be at least 12 inch deep, with cover.

1) Install at least one test well for each service unless otherwise indicated. Install at ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

5. Grounding at Service:

a. Equipment grounding conductors and grounding electrode conductors must be connected to ground busbar. Install main bonding jumper between neutral and ground buses.

6. Grounding Separately Derived Systems:

a. Permanent Generators: Install grounding electrode(s) at location of permanent generators having switched neutral connections. Electrode must be connected to equipment grounding conductor and to frame of generator.

7. Grounding Underground Distribution System Components:

a. Duct-Bank Grounding Conductor: Bury 12 inch above duct bank when indicated as part of duct-bank installation.
b. Comply with IEEE C2 grounding requirements.

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c. Grounding Manholes and Handholes: Install driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inch will extend above finished floor. If necessary, install ground rod before manhole is placed and provide 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inch above to 6 inch below concrete. Seal floor opening with waterproof, nonshrink grout.

d. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields in accordance with manufacturer's published instructions with splicing and termination kits.

e. Pad-Mounted Transformers and Switches: Install two ground rods and ring electrode around pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than 2 AWG for ring electrode and for taps to equipment grounding terminals. Bury ring electrode not less than 6 inch from foundation.

8. Equipment Grounding and Bonding:

a. Install insulated equipment grounding conductors with feeders and branch circuits.

b. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1) Feeders and branch circuits.
2) Lighting circuits.
3) Receptacle circuits.
4) Single-phase motor and appliance branch circuits.
5) Three-phase motor and appliance branch circuits.
6) Flexible raceway runs.
7) Armored and metal-clad cable runs.
8) X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

c. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

d. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

e. Isolated Equipment Enclosure Circuits: For designated equipment supplied by branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure and install separate insulated equipment grounding

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conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of applicable derived system or service unless otherwise indicated.

f. Poles Supporting Outdoor Lighting Fixtures: Bond insulated equipment grounding conductor to equipment grounding terminal inside pole base.

g. Metallic Fences: Comply with requirements of IEEE C2.

1) Grounding Conductor: Bare, tinned copper, not less than 8 AWG.
2) Gates: Must be bonded to grounding conductor with flexible bonding jumper.
3) Barbed Wire: Strands must be bonded to grounding conductor.

3.5 FIELD QUALITY CONTROL FOR GROUNDING AND BONDING

A. Acceptance Testing Preparation:

B. Field tests and inspections must be witnessed by authorities having jurisdiction.

C. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
3. Test completed grounding system at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before conductors are connected.

a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
b. Perform tests by fall-of-potential method in accordance with IEEE Std 81.
c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to record of tests and observations. Include number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

D. Nonconforming Work:

1. Grounding system will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective components and retest.

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E. Collect, assemble, and submit test and inspection reports.

1. Report measured ground resistances that exceed the following values:

a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 Ω.
b. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 Ω.
c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 Ω.
d. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 Ω.
e. Pad-Mounted Equipment: 5 Ω.

3.6 PROTECTION

A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 05 26

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SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Support, anchorage, and attachment components.
2. Fabricated metal equipment support assemblies.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Slotted support systems, hardware, and accessories.
b. Clamps.
c. Hangers.
d. Sockets.
e. Eye nuts.
f. Fasteners.
g. Anchors.
h. Saddles.
i. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

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C. Delegated Design Submittals: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified structural professional engineer to design hanger and support system.

B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32 inch diameter holes at a maximum of 8 inch on center in at least one surface.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Allied Tube & Conduit; Atkore International.
c. CADDY; brand of nVent Electrical plc.
d. Cooper B-line; brand of Eaton, Electrical Sector.
e. Unistrut; Atkore International.

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Galvanized steel.
4. Channel Width: Selected for applicable load criteria.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

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B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with minimum 13/32 inch diameter holes at a maximum of 8 inch on center, in at least one surface.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; Atkore International.
b. Cooper B-line; brand of Eaton, Electrical Sector.

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channel Width: Selected for applicable load criteria.
4. Fittings and Accessories: Products provided by channel and angle manufacturer and designed for use with those items.
5. Fitting and Accessory Materials: Same as those for channels and angles, except metal items may be stainless steel.
6. Rated Strength: Selected to suit applicable load criteria.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Hilti, Inc.
2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
3) MKT Fastening, LLC.

2. Mechanical-Expansion Anchors: Insert-wedge-type, [zinc-coated] [stainless] steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

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a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Cooper B-line; brand of Eaton, Electrical Sector.
2) Empire Industries, Inc.
3) Hilti, Inc.
4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325.
6. Toggle Bolts: All steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 SELECTION

A. Comply with the following standards for selection and installation of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA NEIS 101
2. NECA NEIS 105.
3. NECA NEIS 111.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."

D. Comply with requirements for boxes specified in Section 260533.16 "Boxes and Covers for Electrical Systems."

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E. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as required by NFPA 70. Minimum rod size must be 1/4 inch in diameter.

F. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

G. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 INSTALLATION OF SUPPORTS

A. Comply with NECA NEIS 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA NEIS 1, EMT, IMC, and ERMC may be supported by openings through structure members, in accordance with NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination must be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts, Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69, or Spring-tension clamps.
6. To Light Steel: Sheet metal screws.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

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B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M. Submit welding certificates.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inch larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000 psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup:

1. Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

    a. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

2. Comply with requirements in Section 099113 "Exterior Painting", Section 099123 "Interior Painting", and Section 099600 "High-Performance Coatings" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 26 05 29

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SECTION 26 05 33.13

CONDUITS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type EMT-S duct raceways and elbows.
2. Type ERMC-S duct raceways, elbows, couplings, and nipples.
3. Type FMC-S duct raceways.
4. Type IMC duct raceways.
5. Type LFMC duct raceways.
6. Type LFNC duct raceways.
7. Type PVC duct raceways and fittings.
8. Fittings for conduit, tubing, and cable.
9. Electrically conductive corrosion-resistant compounds for threaded conduit.
10. Solvent cements.

B. Products Installed, but Not Furnished, under This Section:

1. See Section 260553 "Identification for Electrical Systems" for electrical equipment labels.

C. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" for nonmetallic underground conduit with conductors (Type NUCC).
3. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior duct banks, manholes, and underground utility construction.

1.2 DEFINITIONS

A. Conduit: A structure containing one or more duct raceways.

B. Duct Raceway: A single enclosed raceway for conductors or cable.

C. Duct Bank: An arrangement of conduit providing one or more continuous duct raceways between two points.

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1.3 ACTION SUBMITTALS

A. Product Data:

1. Type EMT-S duct raceways and elbows.
2. Type ERMC-S duct raceways, elbows, couplings, and nipples.
3. Type FMC-S duct raceways.
4. Type IMC duct raceways.
5. Type LFMC duct raceways.
6. Type LFNC duct raceways.
7. Type PVC duct raceways and fittings.
8. Fittings for conduit, tubing, and cable.
9. Electrically conductive corrosion-resistant compounds for threaded conduit.
10. Solvent cements.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions:

1. Type EMT-S duct raceways and elbows.
2. Type ERMC-S duct raceways, elbows, couplings, and nipples.
3. Type FMC-S duct raceways.
4. Type IMC duct raceways.
5. Type LFMC duct raceways.
6. Type LFNC duct raceways.
7. Type PVC duct raceways and fittings.
8. Fittings for conduit, tubing, and cable.
9. Electrically conductive corrosion-resistant compounds for threaded conduit.
10. Solvent cements.

PART 2 - PRODUCTS

2.1 TYPE EMT-S DUCT RACEWAYS AND ELBOWS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Listing Criteria: UL CCN FJMX; including UL 797.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

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C. UL FJMX - Steel Electrical Metal Tubing (EMT-S) and Elbows:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; Atkore International.
b. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
c. Western Tube; Zekelman Industries.
d. Wheatland Tube; Zekelman Industries.

2. Material: Steel.
3. Options:

a. Exterior Coating: Zinc.
b. Interior Coating: Zinc with organic top coating.
c. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.2 TYPE ERMC-S DUCT RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Listing Criteria: UL CCN DYIX; including UL 6.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DYIX - Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; Atkore International.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
e. Western Tube; Zekelman Industries.
f. Wheatland Tube; Zekelman Industries.

2. Exterior Coating: Zinc.
3. Options:

a. Interior Coating: Zinc with organic top coating.

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b. Minimum Trade Size: Metric designator 21 (trade size 3/4).

D. UL DYIX - PVC-Coated-Steel Electrical Rigid Metal Conduit (ERMC-S-PVC), Elbows, Couplings, and Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Calbond; Atkore International.
c. Plasti-Bond; Robroy Industries.

2. Options:

a. Exterior Coating: PVC complying with NEMA RN 1.
b. Interior Coating: Zinc with organic top coating.
c. Minimum Trade Size: Metric designator 21 (trade size 3/4).
d. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.

2.3 TYPE FMC-S DUCT RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Listing Criteria: UL CCN DXUZ; including UL 1.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DXUZ - Steel Flexible Metal Conduit (FMC-S):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Anaconda Sealtite; Anamet Electrical, Inc.
c. Electri-Flex Company.

2. Material: Steel.
3. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

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2.4 TYPE IMC DUCT RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Listing Criteria: UL CCN DYBY; including UL 1242.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DYBY - Steel Intermediate Metal Conduit (IMC):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Allied Tube & Conduit; Atkore International.
c. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
d. Western Tube; Zekelman Industries.
e. Wheatland Tube; Zekelman Industries.

2. Options:

a. Exterior Coating: Zinc.
b. Interior Coating: Zinc with organic top coating.
c. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.5 TYPE LFMC DUCT RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Listing Criteria: UL CCN DXHR; including UL 360.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DXHR - Steel Liquidtight Flexible Metal Conduit (LFMC-S):

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Anaconda Sealtite; Anamet Electrical, Inc.
    c. Electri-Flex Company.
    d. International Metal Hose Co.

2. Material: Steel.
3. Options:

    a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.6 TYPE LFNC DUCT RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Listing Criteria: UL CCN DXOQ; including UL 1660.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DXOQ - Layered (Type A) Liquidtight Flexible Nonmetallic Conduit (LFNC-A):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. AFC Cable Systems; Atkore International.
    b. Electri-Flex Company.

2. Additional Criteria: Type A conduit with smooth seamless inner core and cover bonded together with one or more reinforcement layers between core and cover.
3. Options:

    a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
    b. Markings: 80 deg C dry and Sunlight resistant.

D. UL DXOQ - Integral (Type B) Liquidtight Flexible Nonmetallic Conduit (LFNC-B):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Cambridge Resources.

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c. Electri-Flex Company.

2. Additional Criteria: Type B conduit with smooth inner surface with integral reinforcement within conduit wall.
3. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
b. Markings: 80 deg C dry and Sunlight resistant.

E. UL DXOQ - Corrugated (Type C) Liquidtight Flexible Nonmetallic Conduit (LFNC-C):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. HellermannTyton.

2. Additional Criteria: Type C conduit with corrugated internal and external surfaces without integral reinforcement within conduit wall.
3. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
b. Markings: 80 deg C dry and Sunlight resistant.

2.7 TYPE PVC DUCT RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Listing Criteria: UL CCN DZYR; including UL 651.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DZYR - Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. JM Eagle.

2. Dimensional Specifications: Schedule 40.
3. Options:

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a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
b. Markings: For use with maximum 90 deg C wire.

D. UL DZYR - Schedule 80 Rigid PVC Conduit (PVC-80) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. JM Eagle.

2. Dimensional Specifications: Schedule 80.
3. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
b. Markings: For use with maximum 90 deg C wire.

E. UL DZYR - Type A Rigid PVC Concrete-Encased Conduit (PVC-A) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Southern Pipe, Inc.

2. Dimensional Specifications: Type A.
3. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

F. UL DZYR - Type EB Rigid PVC Concrete-Encased Underground Conduit (PVC-EB) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. JM Eagle.
b. Southern Pipe, Inc.

2. Dimensional Specifications: Type EB.
3. Options:

a. Minimum Trade Size: Metric designator 53 (trade size 2).

2.8 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

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B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DWTT - Fittings for Type ERMC, Type IMC, and Type PVC Duct Raceways:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Appleton; Emerson Electric Co., Automation Solutions.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
e. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. Southwire Company, LLC.

2. Listing Criteria: UL CCN DWTT; including UL 514B.
3. Options:

a. Material: Steel.
b. Coupling Method: [Compression coupling] [Raintight compression coupling with distinctive color gland nut] [Setscrew coupling. Setscrew couplings with only single screw per conduit are unacceptable].
c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.

D. UL FKAV - Fittings for Type EMT Duct Raceways:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Allied Tube & Conduit; Atkore International.
c. Appleton; Emerson Electric Co., Automation Solutions.
d. Crouse-Hinds; brand of Eaton, Electrical Sector.
e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
g. Southwire Company, LLC.

2. Listing Criteria: UL CCN FKAV; including UL 514B.
3. Options:

a. Material: Steel.
b. Coupling Method: Compression coupling.
c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.

E. UL ILNR - Fittings for Type FMC Duct Raceways:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. American Fittings Corp. (AMFICO).
    b. Liquid Tight Connector Co.
    c. Southwire Company, LLC.

2. Listing Criteria: UL CCN ILNR; including UL 514B.

F. UL DXAS - Fittings for Type LFMC and Type LFNC Duct Raceways:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Arlington Industries, Inc.
    b. Liquid Tight Connector Co.

2. Listing Criteria: UL CCN DXAS; including UL 514B.

2.9 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Listing Criteria: UL CCN FOIZ; including UL Subject 2419.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL FOIZ - Electrically Conductive Corrosion-Resistant Compound for Threaded Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. ABB, Electrification Business.

2.10 SOLVENT CEMENTS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

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2. Listing Criteria: UL CCN DWTT; including UL 514B.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL DWTT - Solvent Cements for Type PVC Duct Raceways and Fittings:

PART 3 - EXECUTION

3.1 SELECTION OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of duct raceways. Consult Architect for resolution of conflicting requirements.

B. Outdoors:

1. Exposed and Subject to Severe Physical Damage: ERMC.
2. Exposed and Subject to Physical Damage: ERMC.
    a. Locations less than 2.5 m (8 ft) above finished floor.
3. Exposed and Not Subject to Physical Damage: ERMC.
4. Concealed Aboveground: ERMC.
5. Direct Buried: PVC-40 or as indicated on drawings.
6. Concrete Encased Not in Trench: PVC-40 or as indicated on drawings.
7. Concrete Encased in Trench: PVC-40 or as indicated on drawings.
8. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFNC-A or LFNC-B in short lengths (minimum eighteen (18) inches, maximum length six (6) feet).

C. Indoors:

1. Exposed and Subject to Severe Physical Damage: ERMC. Locations include the following:
    a. Loading docks.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Mechanical rooms.
    d. Electrical rooms.
2. Exposed and Subject to Physical Damage: ERMC. Locations include the following:
    a. Locations less than 2.5 m (8 ft) above finished floor.
    b. Stub-ups to above suspended ceilings.

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3. Exposed and Not Subject to Physical Damage: EMT.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Damp or Wet Locations: ERMC.
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use Liquidtight Flexible Metallic Conduit in damp or wet locations and in Mechanical Equipment Rooms. Flexible conduit shall be installed in short lengths (minimum eighteen (18) inches, maximum length six (6) feet).

D. Duct Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.

1. ERMC and IMC: Provide threaded-type fittings unless otherwise indicated.

3.2 INSTALLATION OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:

1. Type EMT-S: Article 358 of NFPA 70 and NECA NEIS 101.
2. Type ERMC-S: Article 344 of NFPA 70 and NECA NEIS 101.
3. Type FMC-S: Article 348 of NFPA 70 and NECA NEIS 101.
4. Type IMC: Article 342 of NFPA 70 and NECA NEIS 101.
5. Type LFMC: Article 350 of NFPA 70 and NECA NEIS 101.
6. Type LFNC: Article 342 of NFPA 70 and NECA NEIS 111.
7. Type PVC: Article 356 of NFPA 70 and NECA NEIS 111.
8. Expansion Fittings: NEMA FB 2.40.
9. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. General Requirements for Installation of Duct Raceways:

a. Complete duct raceway installation before starting conductor installation.
b. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft above finished floor.
c. Install no more than equivalent of three 90-degree bends in conduit run except for control wiring conduits, for which no more than equivalent of two 90-degree fewer bends are permitted. Support within 12 inch of changes in direction.
d. Make bends in duct raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
e. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
f. Support conduit within 12 inch of enclosures to which attached.

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g. Install duct sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed duct raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install duct sealing fittings in accordance with NFPA 70.

h. Install devices to seal duct raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of duct raceways at the following points:

1) Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2) Where an underground service duct raceway enters a building or structure.
3) Conduit extending from interior to exterior of building.
4) Conduit extending into pressurized duct raceway and equipment.
5) Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6) Where otherwise required by NFPA 70.

i. Do not install conduits within 2 inch of the bottom side of a metal deck roof.

j. Keep duct raceways at least 6 inch away from parallel runs of flues and steam or hot-water pipes. Install horizontal duct raceway runs above water and steam piping.

k. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.

l. Install pull wires in empty duct raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb tensile strength. Leave at least 12 inch of slack at both ends of pull wire. Cap underground duct raceways designated as spare above grade alongside duct raceways in use.

m. Install duct raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.

1) Termination fittings with shoulders do not require two locknuts.

n. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to metric designator 35 (trade size 1-1/4) and insulated throat metal bushings on metric designator 41 (trade size 1-1/2) and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

2. Types ERMC and IMC:

a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of duct raceway and fittings before making up joints. Follow compound manufacturer's published instructions.

3. Types FMC, LFMC, and LFNC:

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a. Provide a maximum of 72 inch of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

4. Types PVC:

a. Do not install Type PVC conduit where ambient temperature exceeds 122 deg F. Conductor ratings must be limited to 75 deg C except where installed in a trench outside buildings with concrete encasement, where 90 deg C conductors are permitted.
b. Comply with manufacturer's published instructions for solvent welding and fittings.

5. Duct Raceways Embedded in Slabs:

a. Run duct raceways larger than metric designator 27 (trade size 1) below concrete slab.
b. Arrange duct raceways to cross building expansion joints with expansion fittings at right angles to the joint.
c. Arrange duct raceways to ensure that each is surrounded by minimum of 2 inch of concrete without voids.
d. Do not embed threadless fittings in concrete unless locations have been specifically approved by Architect.

6. Stub-ups to Above Recessed Ceilings:

a. Provide EMT, IMC, or ERMC for duct raceways.
b. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

7. Duct Raceway Terminations at Locations Subject to Moisture or Vibration:

a. Provide insulating bushings to protect conductors, including conductors smaller than 4 AWG. Install insulated throat metal grounding bushings on service conduits.

8. Duct Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.

a. EMT: Provide compression steel fittings. Comply with NEMA FB 2.10.
b. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.

9. Expansion-Joint Fittings:

a. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 30 deg F and that have straight-run length that exceeds 25 ft. Install in runs of aboveground ERMC and EMT conduit that are located where environmental temperature change may exceed 100 deg F and that have straight-run length that exceeds 100 ft.
b. Install type and quantity of fittings that accommodate temperature change listed for the following locations:

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1) Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
2) Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
3) Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
4) Attics: 135 deg F temperature change.

c. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
d. Install expansion fittings at locations where conduits cross building or structure expansion joints.
e. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's published instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

10. Duct Raceways Penetrating Rooms or Walls with Acoustical Requirements: Seal duct raceway openings on both sides of rooms or walls with acoustically rated putty or firestopping.
11. Identification: Provide labels for conduit assemblies, duct raceways, and associated electrical equipment.

a. Provide warning signs.

3.3 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 05 33.13

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SECTION 26 05 33.16

BOXES AND COVERS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metallic outlet boxes, device boxes, rings, and covers.
2. Junction boxes and pull boxes.
3. Cover plates for device boxes.
4. Hoods for outlet boxes.

B. Products Installed, but Not Furnished, under This Section:

1. See Section 260553 "Identification for Electrical Systems" for electrical equipment labels.

C. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Metallic outlet boxes, device boxes, rings, and covers.
2. Junction boxes and pull boxes.
3. Cover plates for device boxes.
4. Hoods for outlet boxes.

B. Shop Drawings:

1. Shop drawings for floor boxes.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions:

1. Metallic outlet boxes, device boxes, rings, and covers.
2. Junction boxes and pull boxes.
3. Cover plates for device boxes.
4. Hoods for outlet boxes.

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PART 2 - PRODUCTS

2.1 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria: UL CCN QCIT; including UL 514A.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
3. Samples:

a. Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
b. Raised Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
c. Recessed Access-Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
d. Concrete Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.

C. UL QCIT - Metallic Outlet Boxes and Covers:

1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides of the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Appleton; Emerson Electric Co., Automation Solutions.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

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g. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
h. Pass & Seymour; Legrand North America, LLC.
i. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
j. Wiremold; Legrand North America, LLC.

3. Options:

a. Material: Sheet steel.
b. Sheet Metal Depth: Minimum 3.5 inch.
c. Luminaire Outlet Boxes and Covers: Nonadjustable, listed and labeled for attachment of luminaire weighing more than 50 lb and marked with maximum allowable weight.
d. Paddle Fan Outlet Boxes and Covers: Nonadjustable, designed for attachment of paddle fan weighing up to 70 lb.

D. UL QCIT - Metallic Conduit Bodies:

1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Appleton; Emerson Electric Co., Automation Solutions.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
f. Pass & Seymour; Legrand North America, LLC.
g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

E. UL QCIT - Metallic Device Boxes:

1. Description: Box with provisions for mounting wiring device directly to box.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Appleton; Emerson Electric Co., Automation Solutions.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
g. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
h. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

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3. Options:

    a. Material: Sheet steel.
    b. Sheet Metal Depth: minimum 3.5 inch.

F. UL QCIT - Metallic Extension Rings:

1. Description: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Appleton; Emerson Electric Co., Automation Solutions.
    c. Crouse-Hinds; brand of Eaton, Electrical Sector.
    d. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
    f. Pass & Seymour; Legrand North America, LLC.
    g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

G. UL QCIT - Metallic Floor Boxes and Floor Box Covers:

1. Description: Box mounted in floor with floor box cover and other components to complete floor box enclosure.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. AFC Cable Systems; Atkore International.
    c. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    d. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    e. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    f. Leviton Manufacturing Co., Inc.
    g. Pass & Seymour; Legrand North America, LLC.
    h. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    i. Wiremold; Legrand North America, LLC.

H. UL QCIT - Metallic Raised-Floor Boxes and Floor Box Covers:

1. Description: Box mounted in raised-floor with floor box cover and other components to complete floor box enclosure.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

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c. Wiremold; Legrand North America, LLC.

I. UL QCIT - Metallic Concrete Boxes and Covers:

1. Description: Box intended for use in poured concrete.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. Wiremold; Legrand North America, LLC.

2.2 JUNCTION BOXES AND PULL BOXES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. Listing Criteria: UL CCN BGUZ; including UL 50 and UL 50E.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL BGUZ - Indoor Sheet Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Appleton; Emerson Electric Co., Automation Solutions.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. Hoffman; brand of nVent Electrical plc.
d. Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
h. Square D; Schneider Electric USA.

3. Options:

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a. Degree of Protection: Type 1.

D. UL BGUZ - Indoor Cast-Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Appleton; Emerson Electric Co., Automation Solutions.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.

3. Options:

a. Degree of Protection: Type 1.

E. UL BGUZ - Indoor Polymeric Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Allied Tube & Conduit; Atkore International.
c. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

3. Options:

a. Degree of Protection: Type 1.

F. UL BGUZ - Outdoor Sheet Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Appleton; Emerson Electric Co., Automation Solutions.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. Hoffman; brand of nVent Electrical plc.
d. Hubbell Industrial Controls; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

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h. Square D; Schneider Electric USA.

3. Options:

a. Degree of Protection: Type 3R.

G. UL BGUZ - Outdoor Cast-Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Appleton; Emerson Electric Co., Automation Solutions.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.

3. Options:

a. Degree of Protection: Type 3R.

H. UL BGUZ - Outdoor Polymeric Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Allied Tube & Conduit; Atkore International.
c. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

3. Options:

a. Degree of Protection: Type 3R.

2.3 COVER PLATES FOR DEVICES BOXES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. Listing Criteria: UL CCN QCIT or UL CCN QCMZ; including UL 514D.
3. Wallplate-Securing Screws: Metal with head color to match wallplate finish.

B. Source Quality Control:

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1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL QCIT or QCMZ - Metallic Cover Plates for Device Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. ABB, Electrification Business.
   b. Appleton; Emerson Electric Co., Automation Solutions.
   c. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   d. Crouse-Hinds; brand of Eaton, Electrical Sector.
   e. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   f. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   g. Intermatic, Inc.
   h. Leviton Manufacturing Co., Inc.
   i. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
   j. Panduit Corp.
   k. Pass & Seymour; Legrand North America, LLC.
   l. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   m. Wiremold; Legrand North America, LLC.

2. Options:

   a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
   b. Wallplate Material: 0.032 inch thick, Type 302/304 non-magnetic stainless steel with brushed finish.

2.4 HOODS FOR OUTLET BOXES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. Listing Criteria:

   a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
   b. Receptacle, Hood, Cover Plate, Gaskets, and Seals: UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.

3. Mounts to box using fasteners different from wiring device.

B. Source Quality Control:

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1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL QCIT or QCMZ - Retractable or Reattachable Hoods for Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. ABB, Electrification Business.
   b. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. Options:

   a. Provides clear, weatherproof, "while-in-use" cover.

D. UL QCIT or QCMZ - Extra-Duty, While-in-Use Hoods for Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. ABB, Electrification Business.
   b. Allied Tube & Conduit; Atkore International.
   c. Appleton; Emerson Electric Co., Automation Solutions.
   d. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   e. Intermatic, Inc.
   f. Leviton Manufacturing Co., Inc.
   g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. Additional Characteristics: Marked "Extra-Duty" in accordance with UL 514D.
3. Options:

   a. Provides clear, weatherproof, "while-in-use" cover.
   b. Manufacturer may combine nonmetallic device box with hood as extra-duty rated assembly.

PART 3 - EXECUTION

3.1 PREPARATION

A. Shop Drawings: Prepare and submit the following:

1. Shop Drawings for Floor Boxes: Show that floor boxes are located to avoid interferences and are structurally allowable. Indicate floor thickness at location where boxes are embedded in concrete floors and underfloor clearances where boxes are installed in raised floors.

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3.2 SELECTION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.

B. Degree of Protection:

1. Outdoors:

a. Type 3R unless otherwise indicated.
b. Locations Exposed to Hosedown: Type 4.
c. Locations Subject to Potential Flooding: Type 6P.
d. Locations Aboveground Where Mechanism Must Operate When Ice Covered: Type 3S.
e. Locations in-Ground or Exposed to Corrosive Agents: Type 4X.
f. Locations in-Ground or Exposed to Corrosive Agents Where Mechanism Must Operate When Ice Covered: Type 3SX.

2. Indoors:

a. Type 1 unless otherwise indicated.
b. Damp or Dusty Locations: Type 4.
c. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
d. Flush Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
e. Locations Exposed to Airborne Dust, Lint, Fibers, or Flyings: Type 4.
f. Locations Exposed to Hosedown: Type 4.
g. Locations Exposed to Corrosive Agents: Type 4X.
h. Locations Exposed to Spraying Oil or Coolants: Type 13.

C. Exposed Boxes Installed Less Than 2.5 m (8 ft) Above Floor:

1. Provide cast-metal boxes.
2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

3.3 INSTALLATION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:

1. Outlet, Device, Pull, and Junction Boxes: Article 314 of NFPA 70.
2. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

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1. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.
2. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
3. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box, whether installed indoors or outdoors.
4. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
5. Locate boxes so that cover or plate will not span different building finishes.
6. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.
7. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.
8. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.
9. Set metal floor boxes level and flush with finished floor surface.
10. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
11. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.
12. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
13. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:

    a. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
    b. Provide gaskets for wallplates and covers.

14. Identification: Provide labels for boxes and associated electrical equipment.

    a. Identify field-installed conductors, interconnecting wiring, and components.
    b. Provide warning signs.
    c. Label each box with engraved metal or laminated-plastic nameplate.

3.4 CLEANING

A. Remove construction dust and debris from boxes before installing wallplates, covers, and hoods.

3.5 PROTECTION

A. After installation, protect boxes from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 05 33.16

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SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type ERMC-S raceways, elbows, couplings, and nipples.
2. Type IMC raceways.
3. Type PVC raceways and fittings.
4. Fittings for conduit, tubing, and cable.
5. Electrically conductive corrosion-resistant compounds for threaded conduit.
6. Solvent cements.
7. Duct accessories.
8. Handholes and boxes for exterior underground wiring.
9. Duct sealing.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" specifies additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" specifies nonmetallic underground conduit with conductors (Type NUCC).
3. Section 260553 "Identification for Electrical Systems" specifies underground-line warning tape and concrete cable routing markers (warning planks).

1.2 DEFINITIONS

A. Duct: A single raceway or multiple raceways, installed singly or as components of a duct bank.

B. Duct Bank: Two or more ducts installed in parallel, direct buried or with additional casing materials such as concrete.

C. Handhole: An underground chamber containing electrical cables, sized such that personnel are not required to enter in order to access the cables.

D. Manhole: An underground chamber containing electrical cables and equipment, sized to provide access with working space clearances.

E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

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1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For concrete and steel used in precast concrete manholes and handholes, also include product certificates as required by ASTM C858.

B. Shop Drawings:

1. Electric Utility Duct Banks and Structures:

a. Include plans, elevations, sections, and details, including attachments to other Work.
b. Indicate locations of private property boundaries and utility easements.
c. Include information required for approval by electric utility and for obtaining public space utility work permits.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including locations and duct sizes, and methods and materials for waterproofing duct entry locations.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and other accessories.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

B. Field Reports:

1. Factory Test Reports: For handholes and boxes.
2. Manufacturer's field reports for field quality-control support.

PART 2 - PRODUCTS

2.1 TYPE ERMC-S RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 6 and UL CCN DYIX.

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B. Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; Atkore International.
b. Calconduit; Atkore International.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
e. Patriot Aluminum Products, LLC.
f. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
g. Topaz Lighting & Electric.
h. Western Tube; Zekelman Industries.
i. Wheatland Tube; Zekelman Industries.

2. Exterior Coating: Zinc.
3. Options:

a. Interior Coating: Zinc with organic top coating.
b. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.2 TYPE IMC RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1242 and UL CCN DYBY.

B. Steel Electrical Intermediate Metal Conduit (IMC):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Allied Tube & Conduit; Atkore International.
c. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
d. Western Tube; Zekelman Industries.
e. Wheatland Tube; Zekelman Industries.

2. Options:

a. Exterior Coating: Zinc.
b. Interior Coating: Zinc with organic top coating.
c. Minimum Trade Size: Metric designator 21 (trade size 3/4).

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2.3 TYPE PVC RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 651 and UL CCN DZYR.

B. Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Calconduit; Atkore International.
c. JM Eagle.
d. NAPCO; Westlake Chemical Corp.

2. Dimensional Specifications: Schedule 40.
3. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
b. Markings: For use with maximum 90 deg C wire.

C. Schedule 80 Rigid PVC Conduit (PVC-80) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Calconduit; Atkore International.
c. JM Eagle.

2. Dimensional Specifications: Schedule 80.
3. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
b. Markings: For use with maximum 90 deg C wire.

D. Type A Rigid PVC Concrete-Encased Conduit (PVC-A) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Southern Pipe, Inc.

2. Dimensional Specifications: Type A.
3. Options:

a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

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E. Type EB Rigid PVC Concrete-Encased Underground Conduit (PVC-EB) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. JM Eagle.
b. Southern Pipe, Inc.

2. Dimensional Specifications: Type EB.
3. Options:

a. Minimum Trade Size: Metric designator 53 (trade size 2).

2.4 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

B. Metallic Fittings for Type ERMC, Type IMC, Type PVC, Type EPEC, and Type RTRC Raceways:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Appleton; Emerson Electric Co., Automation Solutions.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
e. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. Southwire Company, LLC.

2. General Characteristics: UL 514B and UL CCN DWTT.
3. Options:

a. Material: Steel.
b. Coupling Method: Compression coupling.
c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

2.5 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

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2. General Characteristics: UL Subject 2419 and UL CCN FOIZ.

B. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. ABB, Electrification Business.

2.6 SOLVENT CEMENTS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: As recommended by conduit manufacturer in accordance with UL 514B and UL CCN DWTT.

B. Solvent Cements for Type PVC Raceways and Fittings:

2.7 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Allied Tube & Conduit; Atkore International.

2.8 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:

a. ASTM C858 for design and manufacturing processes.
b. SCTE 77.

B. Fiberglass Handholes and Boxes:

1. Description: Molded of fiberglass-reinforced polyester resin, with covers made of reinforced fiberglass.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. MacLean Highline.
b. Nordic Fiberglass, Inc.

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c. Oldcastle Infrastructure Inc.; CRH Americas.
d. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.

3. Configuration: Units must be designed for flush burial and have open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
b. Cover Legend: Molded lettering, "ELECTRIC" as indicated for each service.

5. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
6. Duct Entrance Provisions: Duct-terminating fittings must mate with entering duct for secure, fixed installation in enclosure wall.
7. Handholes 12 inch wide by 24 inch long and larger must have factory-installed inserts for cable racks and pulling-in irons.
8. Options:

a. Color: Green.

2.9 DUCT SEALING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Electrification Business.
2. American Polywater Corporation.
3. CommScope, Inc.
4. Gardner Bender.

B. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Compound must be capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals. Duct sealing compound must be removable without damaging ducts or cables.

C. Inflatable Duct-Sealing System: Wraparound inflatable bladder that seals ducts that are empty or containing conductors against air and water infiltration. System is suitable for use in steel, plastic, or concrete ducts and penetrations.

2.10 SOURCE QUALITY CONTROL

A. Factory Tests for Handholes and Boxes:

1. Testing Administrant: Engage qualified structural testing agency to evaluate handholes and boxes.

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a. Strength tests of complete boxes and covers must be by independent testing agency or manufacturer. Qualified registered professional engineer must certify tests by manufacturer.

2. Factory Tests and Inspections: Perform the following tests and inspections on handholes and boxes, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, before delivering to site. Affix label with name and date of qualified testing laboratory's certification of system compliance.

a. Precast Concrete Utility Structures: Test and inspect in accordance with ASTM C1037.
b. Polymer Concrete and Nonconcrete Handhole and Pull-Box Prototypes: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests must be for specified tier ratings of products supplied. Testing machine pressure gages must have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

3. Nonconforming Work:

a. Equipment that does not pass tests and inspections will be considered defective.

4. Factory Test Reports: Prepare and submit factory test and inspection reports.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in field. Notify Architect if there is conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.

C. Clear and grub vegetation to be removed and protect vegetation to remain in accordance with Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication in accordance with Section 311000 "Site Clearing."

3.2 SELECTION OF UNDERGROUND DUCTS

A. Duct for Electrical Feeders 600 V and Less: PVC-40 concrete encased unless otherwise indicated.

B. Duct for Electrical Branch Circuits: PVC-40, direct buried unless otherwise indicated.

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C. Underground Ducts Crossing Paved Paths Walks and Driveways: PVC-80.

D. Underground Ducts Crossing Roadways: PVC-80, encased in reinforced concrete.

3.3 SELECTION OF UNDERGROUND ENCLOSURES

A. Handholes and Boxes:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-10 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Fiberglass-reinforced polyester resin, SCTE 77, Tier 15 structural load rating.
3. Units in Sidewalk and Similar Applications with Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested in accordance with SCTE 77 with 3000 lbf vertical loading.
5. Cover design load must not exceed load rating of handhole or box.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restoration: Restore area immediately after backfilling is completed or after construction vehicle traffic in immediate area is complete.

C. Restore surface features at areas disturbed by excavation and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."

E. Cut and patch existing pavement in path of underground duct, duct bank, and underground structures in accordance with "Cutting and Patching" Article in Section 017300 "Execution."

3.5 INSTALLATION OF DUCTS AND DUCT BANKS

A. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA TCB 2 for installation of underground ducts and duct banks.
2. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

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1. Where indicated on Drawings, install duct, spacers, and accessories into duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
2. Slope: Pitch duct minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from high point between two manholes to drain in both directions.
3. Expansion and Deflection Fittings: Install expansion and deflection fitting in each duct in area of disturbed earth adjacent to manhole or handhole.
4. Install expansion fitting near center of straight line duct with calculated expansion of more than 3/4 inch.
5. Curves and Bends:

    a. Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with minimum radius of 48 inch, both horizontally and vertically, at other locations unless otherwise indicated.
    b. Field bending must be in accordance with NFPA 70 minimum radii requirements, except bends over 45 degrees must be made with minimum radius of 48 inch. Use only equipment specifically designed for material and size involved. Use PVC heating bender for bending PVC conduit.
    c. Duct must have maximum of 180 degrees of bends between pull points.

6. Joints: Use solvent-cemented joints in nonmetallic duct and fittings and make watertight in accordance with manufacturer's published instructions. Stagger couplings so those of adjacent duct do not lie in same plane. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with minimum 3 inch of concrete for minimum of 12 inch on each side of coupling.

    a. Install insulated grounding bushings on steel raceway terminations that are less than 12 inch below grade or floor level and do not terminate in hubs.

7. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing duct will not be subject to environmental temperatures above 104 deg F. Where environmental temperatures are calculated to rise above 104 deg F, and anywhere duct crosses above underground steam line, install insulation blankets listed for direct burial to isolate duct bank from steam line to maintain maximum environmental temperature of 104 deg F.
8. Building Wall Penetrations: Make transition from underground duct to steel raceway at least 10 ft outside building wall, without reducing duct line slope away from building and without forming trap in line. Use fittings manufactured for transition to steel raceway type installed. Install steel raceway penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
9. Install manufactured steel raceway elbows for stub-ups at poles unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.

    a. Couple steel elbows to ducts with adapters designed for this purpose and encase coupling with minimum 3 inch of concrete for minimum of 12 inch on each side of coupling.

10. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15 psig hydrostatic pressure.

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11. Pulling Cord: Install 200 lbf test nylon cord in empty ducts.
12. Concrete-Encased Ducts and Duct Bank:

    a. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes 6 inch or less in nominal diameter.
    b. Width: Excavate trench 12 inch wider than duct on each side.
    c. Depth: Install so top of duct envelope is at least 24 inch below finished grade in areas not subject to deliberate traffic, and at least 30 inch below finished grade in deliberate traffic paths for vehicles unless otherwise indicated. Install so top of duct envelope is below local frost line.
    d. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
    e. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 ft of duct. Place spacers within 24 inch of duct ends. Stagger spacers approximately 6 inch between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
    f. Minimum Space between Ducts: 3 inch between edge of duct and exterior envelope wall, 2 inch between ducts for like services, and 4 inch between power and communications ducts.
    g. Elbows:

        1) Use manufactured duct elbows for stub-ups and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.

    h. Stub-ups to Outdoor Equipment: Extend concrete-encased steel raceway horizontally minimum of 60 inch from edge of equipment base.

        1) Stub-ups must be minimum 4 inch above finished floor and minimum 3 inch from conduit side to edge of slab.

    i. Stub-ups to Indoor Equipment: Extend concrete-encased steel raceway horizontally minimum of 60 inch from edge of wall. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups must be minimum 4 inch above finished floor and no less than 3 inch from conduit side to edge of slab.

    j. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
    k. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
    l. Concrete Cover: Install minimum of 3 inch of concrete cover between edge of duct to exterior envelope wall, 2 inch between duct of like services, and 4 inch between power and communications ducts.
    m. Place minimum 6 inch of engineered fill above concrete encasement of duct.

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n. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

1) Start at one end and finish at other, allowing for expansion and contraction of duct as its temperature changes during and after pour. Use expansion fittings installed in accordance with manufacturer's published instructions, or use other specific measures to prevent expansion-contraction damage.
2) If more than one pour is necessary, terminate each pour in vertical plane and install 3/4 inch reinforcing-rod dowels extending minimum of 18 inch into concrete on both sides of joint near corners of envelope.

o. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

13. Direct-Buried Duct and Duct Bank:

a. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inch in nominal diameter.
b. Width: Excavate trench 12 inch wider than duct on each side.
c. Depth: Install top of duct at least 36 inch below finished grade unless otherwise indicated.
d. Set elevation of top of duct bank below frost line.
e. Place minimum 3 inch of sand as bed for duct. Place sand to minimum of 6 inch above top level of duct.
f. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
g. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than [four] [five] spacers per 20 ft of duct. Place spacers within 24 inch of duct ends. Stagger spacers approximately 6 inch between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
h. Install duct with minimum of 3 inch between ducts for like services and 6 inch between power and communications duct.
i. Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
j. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inch over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete

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backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.

14. Warning Planks: Bury warning planks approximately 12 inch above direct-buried duct, placing them 36 inch o.c. Align planks along width and along centerline of duct or duct bank. Provide additional plank for each 12 inch increment of duct-bank width over nominal 18 inch. Space additional planks 12 inch apart, horizontally across width of ducts.
15. Underground-Line Warning Tape: Bury conducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inch above concrete-encased duct and duct banks and approximately 12 inch below grade. Align tape parallel to and within 3 inch of centerline of duct bank. Provide additional warning tape for each 12 inch increment of duct-bank width over nominal 18 inch. Space additional tapes 12 inch apart, horizontally across width of ducts.
16. Ground ducts and duct banks in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Reference Standards:

1. Consult Engineer for resolution of conflicting requirements.

B. Special Techniques:

1. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.
2. Unless otherwise indicated, support units on level bed of crushed stone or gravel, graded from 1/2 inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
3. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.
4. Install handholes and boxes with bottom below frost line, below grade.
5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
6. Field cut openings for duct in accordance with enclosure manufacturer's published instructions. Cut wall of enclosure with tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
7. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour concrete ring encircling, and in contact with enclosure entry, and with top surface screeded to top of box cover frame. Bottom of ring must rest on compacted earth.

    a. Concrete: 3000 psi, 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with troweled finish.
    b. Dimensions: 10 inch wide by 12 inch deep.

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8. Ground handholes and boxes in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

B. Field tests and inspections must be witnessed by authorities having jurisdiction.

C. Tests and Inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide minimum 12 inch long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

D. Nonconforming Work:

1. Underground ducts, raceways, and structures will be considered defective if they do not pass tests and inspections.
2. Correct deficiencies and retest as specified above to demonstrate compliance.

E. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

F. Manufacturer Services: Engage factory-authorized service representative to support field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.8 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION 26 05 43

NOT FOR BIDDING PURPOSES

SECTION 26 05 44

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Round sleeves.
2. Rectangular sleeves.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Pourable sealants.
7. Foam sealants.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 ROUND SLEEVES

A. Steel Wall Sleeves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advance Products & Systems, LLC.
b. CCI Piping Systems.
c. Flexicraft Industries.
d. GPT; a division of EnPRO Industries.
e. Specified Technologies Inc.

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2. General Characteristics: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends and integral waterstop.

B. PVC Pipe Sleeves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. CCI Piping Systems.
b. GPT; a division of EnPRO Industries.
c. Metraflex Company (The).

2. General Characteristics: ASTM D1785, Schedule 40.

C. PVC Molded Sleeves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. American Polywater Corporation.
c. Arlington Industries, Inc.
d. Reliance Worldwide Corporation.
e. Roxtec Inc.

2. General Characteristics: With nailing flange for attaching to wooden forms.

D. PE or PP Molded Sleeves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Polywater Corporation.
b. Crete-Sleeve.

2. General Characteristics: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

E. Round, Galvanized-Steel, Sheet Metal Sleeves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Benefast.
b. Specified Technologies Inc.

2. General Characteristics: Galvanized-steel sheet; thickness not less than 0.0239 inch; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

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2.2 RECTANGULAR SLEEVES

A. Rectangular, Galvanized-Steel, Sheet Metal Sleeves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Abesco Fire LLC.
b. Specified Technologies Inc.
c. Wiremold; Legrand North America, LLC.
d. Roxtec Inc.

2. General Characteristics:

a. Material: Galvanized sheet steel.
b. Minimum Metal Thickness:

1) For sleeve cross-section rectangle perimeter less than 50 inch and with no side larger than 16 inch, thickness must be 0.052 inch.
2) For sleeve cross-section rectangle perimeter not less than 50 inch or with one or more sides larger than 16 inch, thickness must be 0.138 inch.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advance Products & Systems, LLC.
2. American Polywater Corporation.
3. BWM Company.
4. CALPICO, Inc.
5. Flexicraft Industries.
6. GPT; a division of EnPRO Industries.
7. Metraflex Company (The).
8. Proco Products, Inc.
9. Roxtec Inc.

B. General Characteristics: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable or between raceway and cable.

C. Options:

1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

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2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Holdrite; a division of Reliance Worldwide Corporation.

B. General Characteristics: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit must have plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Specified Technologies Inc.
2. W. R. Meadows, Inc.

B. General Characteristics: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Design Mix: 5000 psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.6 POURABLE SEALANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carlisle Syntec Systems.
2. GAF.
3. Johns Manville; a Berkshire Hathaway company.
4. Specified Technologies Inc.

B. Performance Criteria:

1. General Characteristics: Single-component, neutral-curing elastomeric sealants of grade indicated below.

a. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

2.7 FOAM SEALANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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1. Innovative Chemical Products (Building Solutions Group).
2. The Dow Chemical Company.

B. Performance Criteria:

1. General Characteristics: Multicomponent, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam. Foam expansion must not damage cables or crack penetrated structure.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Sleeves for Conduits Penetrating Above-Grade, Non-Fire-Rated, Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall or floor so no voids remain. Tool exposed surfaces smooth; protect material while curing.
b. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4 inch annular clear space between sleeve and raceway or cable.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inch above finished floor level. Install sleeves during erection of floors.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Wall Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for wall assemblies.

C. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

D. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve-seal systems. Size sleeves to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

E. Underground, Exterior-Wall and Floor Penetrations:

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1. Install steel pipe sleeves with integral waterstops. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Install sleeve during construction of floor or wall.

3.2 INSTALLATION OF RECTANGULAR SLEEVES AND SLEEVE SEALS

A. Install sleeves in existing walls without compromising structural integrity of walls. Do not cut structural elements without reinforcing the wall to maintain the designed weight bearing and wall stiffness.

B. Install conduits and cable with no crossings within the sleeve.

C. Fill opening around conduits and cables with expanding foam without leaving voids.

D. Provide metal sheet covering at both wall surfaces and finish to match surrounding surfaces. Metal sheet must be same material as sleeve.

3.3 INSTALLATION OF SLEEVE-SEAL SYSTEMS

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

END OF SECTION 26 05 44

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SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Labels.
2. Extruded insulating tubing.
3. Bands.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Identification Schedule: For each piece of electrical equipment and electrical system components to be index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 LABELS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria: UL CCN PGDQ2 for components; including UL 969.

B. UL PGDQ2 - Vinyl Wraparound Labels: Preprinted, flexible labels laminated with clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

NOT FOR BIDDING PURPOSES

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Brady Corporation.
    b. Champion America.
    c. Grafoplast Wire Markers.
    d. HellermannTyton.
    e. LEM Products Inc.
    f. Marking Services Inc.
    g. Panduit Corp.
    h. Seton Identification Products; a Brady Corporation company.
    i. emedco.

C. UL PGDQ2 - Self-Adhesive Wraparound Labels: Preprinted, 3 mil thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. A'n D Cable Products.
    b. Brady Corporation.
    c. Brother International Corporation.
    d. Grafoplast Wire Markers.
    e. Ideal Industries, Inc.
    f. LEM Products Inc.
    g. Marking Services Inc.
    h. Panduit Corp.
    i. Seton Identification Products; a Brady Corporation company.
    j. emedco.

2. Self-Lamination: Clear; UV-, weather-, and chemical-resistant; self-laminating, with protective shield over legend. Size labels such that clear shield overlaps entire printed legend.
3. Marker for Labels:

    a. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. UL PGDQ2 - Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3 mil thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. A'n D Cable Products.
    b. Brady Corporation.
    c. Brother International Corporation.
    d. Grafoplast Wire Markers.
    e. HellermannTyton.
    f. Ideal Industries, Inc.

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g. LEM Products Inc.
h. Marking Services Inc.
i. Panduit Corp.
j. emedco.
k. Seton Identification Products; a Brady Corporation company.

2. Minimum Nominal Size:

a. 1-1/2 by 6 inch for raceway and conductors.
b. 3-1/2 by 5 inch for equipment.
c. As required by authorities having jurisdiction.

2.2 EXTRUDED INSULATING TUBING

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria: UL CCN YDPU2 for components; including UL 224.

B. UL YDPU2 - Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at maximum of 200 deg F.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Panduit Corp.

2.3 BANDS

A. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services Inc.
d. Panduit Corp.
e. Seton Identification Products; a Brady Corporation company.

B. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inch long, with diameters sized to suit diameters and that stay in place by gripping action.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

NOT FOR BIDDING PURPOSES

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services Inc.
d. Panduit Corp.

2.4 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. Champion America.
d. HellermannTyton.
e. Ideal Industries, Inc.
f. Marking Services Inc.
g. Panduit Corp.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mil thick by 1 to 2 inch wide; compounded for outdoor use.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. Marking Services Inc.
d. emedco.

C. Tape and Stencil: 4 inch wide black stripes on 10 inch centers placed diagonally over orange background and are 12 inch wide. Stop stripes at legends.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. HellermannTyton.
b. LEM Products Inc.
c. Marking Services Inc.
d. Pipemarker.com; Brimar Industries, Inc.
e. Seton Identification Products; a Brady Corporation company.

D. Floor Marking Tape: 2 inch wide, 5 mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

NOT FOR BIDDING PURPOSES

a. Brady Corporation.
b. Carlton Industries, LP.
c. Seton Identification Products; a Brady Corporation company.

E. Underground-Line Warning Tape:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Ideal Industries, Inc.
c. LEM Products Inc.
d. Marking Services Inc.
e. Pipemarker.com; Brimar Industries, Inc.
f. Reef Industries, Inc.
g. Seton Identification Products; a Brady Corporation company.

2. Tape:

a. Recommended by manufacturer for method of installation and suitable to identify and locate underground electrical and communications utility lines.
b. Printing on tape must be permanent and may not be damaged by burial operations.
c. Tape material and ink must be chemically inert and not be subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:

a. Comply with APWA Uniform Color Code using NEMA Z535.1 safety colors.
b. Inscriptions for Red Tapes: "CAUTION BURIED ELECTRIC LINE BELOW" <Insert inscription>.
c. Inscriptions for Orange Tapes: "CAUTION BURIED CATV LINE BELOW", "CAUTION BURIED TELEPHONE LINE BELOW", "CAUTION BURIED FIBER OPTIC LINE BELOW", "CAUTION BURIED COMMUNICATION LINE BELOW".

4. Nonconducting Line-Warning Tape:

a. Pigmented polyolefin, bright colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
b. Width: 3 inch.
c. Thickness: 4 mil.
d. Weight: 18.5 lb/1000 sq. ft.
e. Tensile in accordance with ASTM D882: 30 lbf and 2500 psi.

5. Reinforced Nonconducting Line-Warning Tape:

a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
b. Width: 3 inch.

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c. Thickness: 12 mil.
d. Weight: 36.1 lb/1000 sq. ft.
e. Tensile in accordance with ASTM D882: 400 lbf and 11,500 psi.

6. Detectable Line-Warning Tape:

a. Detectable three-layer laminate, consisting of printed pigmented polyolefin film, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
b. Width: 3 inch.
c. Overall Thickness: 5 mil.
d. Foil Core Thickness: 0.35 mil.
e. Weight: 28 lb/1000 sq. ft.
f. Tensile in accordance with ASTM D882: 70 lbf and 4600 psi.

7. Reinforced Detectable Line-Warning Tape:

a. Reinforced, detectable three-layer laminate, consisting of printed pigmented woven scrim, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright-colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
b. Width: 3 inch.
c. Overall Thickness: 8 mil.
d. Foil Core Thickness: 0.35 mil.
e. Weight: 34 lb/1000 sq. ft.
f. Tensile in accordance with ASTM D882: 300 lbf and 12,500 psi.

F. Concrete Cable Route Markers:

1. Description: Concrete markers visually aid tracing the route of electrical cables. Monument markers are typically installed at grade. Protective cover markers are typically installed above the cables at grade or below grade.
2. Product Characteristics:

a. Material: Precast reinforced concrete.
b. Marker Type:

1) Above-Ground Monument Post:

a) Nominal Dimensions (Height, Width, Depth): 30 inch, 6 inch, 3 inch.

2) Above-Ground Monument Block:

a) Nominal Dimensions (Height, Width, Depth): 12 inch, 12 inch, 6 inch.

3) In-Ground Protective Cover (Plank or Slab):

a) Nominal Dimensions (Length, Width, Depth): 36 inch, 6 inch, 2 inch.

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c. Legend: "DANGER - ELECTRICITY", "ELECTRIC CABLES", "ELECTRIC SPLICE".
d. Lettering: Approximately 1/8 inch deep, not less than 1.5 inch high, symmetrically spaced; marked on both sides to allow for reversal.

3. Required Product Options:

a. Color: Red dye added to concrete during batching.
b. Attach metal medallion or sign stamped with feeder number.

G. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height must be 1 inch.

2.5 TAGS

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. Marking Services Inc.
d. Seton Identification Products; a Brady Corporation company.
e. emedco.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. Grafoplast Wire Markers.
d. LEM Products Inc.
e. Marking Services Inc.
f. Panduit Corp.
g. Seton Identification Products; a Brady Corporation company.
h. emedco.

C. Write-on Tags:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.

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c. LEM Products Inc.
d. Pipemarker.com; Brimar Industries, Inc.
e. Seton Identification Products; a Brady Corporation company.

2. Polyester Tags: 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment.
3. Marker for Tags:

a. Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.6 SIGNS

A. Baked-Enamel Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. Champion America.
d. Marking Services Inc.
e. emedco.

2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
3. 1/4 inch grommets in corners for mounting.
4. Nominal Size: 7 by 10 inch.

B. Metal-Backed Butyrate Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Champion America.
c. Marking Services Inc.
d. emedco.

2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396 inch galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
3. 1/4 inch grommets in corners for mounting.
4. Nominal Size: 10 by 14 inch.

C. Laminated Acrylic or Melamine Plastic Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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a. Brady Corporation.
b. Carlton Industries, LP.
c. Marking Services Inc.
d. emedco.
e. Seton Identification Products; a Brady Corporation company.

2. Engraved legend.
3. Thickness:

a. For signs up to 20 sq. inch, minimum 1/16 inch thick.
b. For signs larger than 20 sq. inch, 1/8 inch thick.
c. Engraved legend with black letters on white face.
d. Punched or drilled for mechanical fasteners with 1/4 inch grommets in corners for mounting.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.7 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. HellermannTyton.
2. Ideal Industries, Inc.
3. Marking Services Inc.
4. Panduit Corp.

B. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Listing Criteria: UL CCN ZODZ; including UL 1565 or UL 62275.

C. UL ZODZ - General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F in accordance with ASTM D638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

D. UL ZODZ - UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F in accordance with ASTM D638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

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E. UL ZODZ - Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F in accordance with ASTM D638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 SELECTION OF COLORS AND IDENTIFICATION MARKINGS

A. Comply with 29 CFR 1910.144 for color identification of hazards, and the following:

1. Fire-protection and fire-alarm equipment, including raceways, must be finished, painted, or suitably marked safety red.
2. Ceiling-mounted hangers, supports, cable trays, and raceways must be finished, painted, or suitably marked safety yellow where less than 7.7 ft above finished floor.

B. Pipe and Conduit Labeling: Comply with ASME A13.1 and IEEE C2.

C. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.

1. Color must be factory applied or field applied for sizes larger than 6 AWG when permitted by authorities having jurisdiction.
2. Colors for 208Y/120 V Circuits:

a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.

3. Colors for 480Y/277 V Circuits:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.

4. Color for Neutral (Grounded Conductor): White or gray.
5. Color for Equipment Ground: Green.

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D. Color-Coding Raceways, Cable Trays, Junction Boxes, and Conductors for Intrinsically-Safe Circuits: Light blue. When used to identify intrinsically-safe circuits, Article 504 of NFPA 70 requires that the color light blue not be used for any other purpose.

E. Color-Coding Instructional Signs: Self-adhesive labels, including color code for grounded and ungrounded conductors.

F. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. System legends must be as follows:

1. "EMERGENCY POWER."
2. "POWER."

G. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

H. Locations of Underground Lines: Underground-line warning tape for power and lighting.

I. Handholes, and Pull and Junction Boxes, More Than 1000 V: For conductors in pull and junction boxes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and separate tag with circuit designation.

J. Accessible Raceways, More Than 1000 V: Vinyl wraparound labels.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.
2. Identify system voltage and system or service type with black letters on orange field.

K. Handholes, and Pull and Junction Boxes, 1000 V or Less: For conductors in pull and junction boxes, handholes, use vinyl wraparound labels to identify phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.
2. Identify system voltage and system or service type with black letters on orange field.

L. Accessible Raceways and Metal-Clad Cables, 1000 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.
2. Identify system voltage and system or service type with black letters on orange field.

M. Cover Plates: Label individual cover plates with self-adhesive labels. Place label at top of cover plate. Label cover plate with the following information, in the order listed:

1. Panelboard designation.
2. Colon or dash.
3. Branch circuit number.

N. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in direction of access to live parts. Workspace must comply with NFPA 70 and

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29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

O. Equipment Identification Labels:

1. Black letters on white field.
2. Indoor Equipment: Laminated acrylic or melamine plastic sign.
3. Outdoor Equipment: Laminated acrylic or melamine sign.
4. Equipment to Be Labeled:

   a. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels containing equipment designation.
   b. Panelboards: Typewritten directory of circuits in location provided by panelboard manufacturer. Panelboard identification must be in form of engraved, laminated acrylic or melamine label.
   c. Enclosures and electrical cabinets.
   d. Access doors and panels for concealed electrical items.
   e. Switchgear.
   f. Switchboards.
   g. Transformers: Label that includes tag designation indicated on Drawings for transformer, feeder, and panelboards or equipment supplied by secondary.
   h. Substations.
   i. Emergency system boxes and enclosures.
   j. Enclosed switches.
   k. Enclosed circuit breakers.
   l. Enclosed controllers.
   m. Variable-speed controllers.
   n. Push-button stations.
   o. Power-transfer equipment.
   p. Contactors.
   q. Remote-controlled switches, dimmer modules, and control devices.
   r. Monitoring and control equipment.

P. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 SELECTION OF SIGNS AND HAZARD MARKINGS

A. Comply with 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs.

B. Signs, labels, and tags required for personnel safety must comply with the following standards:

1. Safety Colors: NEMA Z535.1.
2. Facility Safety Signs: NEMA Z535.2.
3. Safety Symbols: NEMA Z535.3.
4. Product Safety Signs and Labels: NEMA Z535.4.
5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.

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C. Electrical Hazard Warnings:

1. Arc-Flash Hazard Warning: Self-adhesive labels. Comply with NFPA 70E and Section 260573.19 "Arc-Flash Hazard Analysis" requirements for arc-flash hazard warning labels.
2. Raceways and Cables Carrying Circuits at More Than 1000 V:

   a. Black letters on orange field.
   b. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

3. Multiple Power Sources Warning Legend: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
4. OSHA Workspace Clearance Warning Legend: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 3 FEET MINIMUM."

D. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels.

1. Apply to exterior of door, cover, or other access.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

   a. Power-transfer switches.
   b. Controls with external control power connections.

E. Operating Instruction Signs: Laminated acrylic or melamine plastic signs.

F. Emergency Operating Instruction Signs: Laminated acrylic or melamine plastic signs with white legend on red background with minimum 3/8 inch high letters for emergency instructions at equipment used for power transfer and load shedding.

3.4 SELECTION OF IDENTIFICATION PRODUCTS FOR COMMUNICATIONS, CONTROL, AUXILIARY, AND LIFE SAFETY SYSTEMS

A. Comply with Section 270528 "Pathways for Communications Systems" and Section 271100 "Communications Equipment Room Fittings."

3.5 INSTALLATION

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes typical for electrical equipment environments specified in Section 260011 "Facility Performance Requirements for Electrical."

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C. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

D. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless steel machine screws with nuts and flat and lock washers.

E. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

F. Install identifying devices before installing acoustical ceilings and similar concealment.

G. Verify identity of item before installing identification products.

H. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

I. Apply identification devices to surfaces that require finish after completing finish work.

J. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.

L. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to location and substrate.

M. Snap-Around Labels: Secure tight to surface at location with high visibility and accessibility.

N. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.

O. Snap-Around Color-Coding Bands: Secure tight to surface at location with high visibility and accessibility.

P. Heat-Shrink, Preprinted Tubes: Secure tight to surface at location with high visibility and accessibility.

Q. Marker Tapes: Secure tight to surface at location with high visibility and accessibility.

R. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility.

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1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for minimum distance of 6 inch where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

S. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

T. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's instructions.

U. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape not less than 12 inch directly above cables or raceways buried 18 inch or more below grade. Use multiple tapes where width of multiple lines installed in common trench [or concrete envelope]exceeds 16 inch overall.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

V. Concrete Cable Route Markers: As indicated on Drawings.

W. Metal Tags:

1. Place in location with high visibility and accessibility.
2. Secure using plenum-rated cable ties.

X. Nonmetallic Preprinted Tags:

1. Place in location with high visibility and accessibility.
2. Secure using plenum-rated cable ties.

Y. Write-on Tags:

1. Place in location with high visibility and accessibility.
2. Secure using plenum-rated cable ties.

Z. Baked-Enamel Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.

AA. Metal-Backed Butyrate Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.

BB. Laminated Acrylic or Melamine Plastic Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.

END OF SECTION 26 05 53

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SECTION 26 05 73.13

SHORT-CIRCUIT STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, fault-current study to determine minimum interrupting capacity of circuit protective devices.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260573.16 "Coordination Studies" for overcurrent protective device coordination studies.
3. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash studies.

1.2 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed and salvaged, or removed and reinstalled. Existing to remain items must remain functional throughout construction period.

B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

F. Single-Line Diagram: See "One-Line Diagram."

1.3 ACTION SUBMITTALS

A. Product Data:

1. For power system analysis software to be used for studies.

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B. Short-Circuit Study Report:

1. Submit the following after approval of system protective devices submittals. Submittals must be in digital form.

a. Short-circuit study input data, including completed computer program input data sheets.
b. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
c. Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.5 QUALITY ASSURANCE

A. Study must be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms must comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. ETAP - Digital Twin Platform.
5. EasyPower, LLC (formerly ESA Inc.).
6. Power Analytics, Corporation.
7. SKM Systems Analysis, Inc.

B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of power systems analysis software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

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D. Computer software program must be capable of plotting and diagramming time-current-characteristic curves as part of its output.

E. Computer program must be designed to perform short-circuit studies or have function, component, or add-on module designed to perform short-circuit studies.

F. Computer program must be developed under supervision of licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kVA and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchboard and panelboard designations and ratings.
6. Derating factors and environmental conditions.
7. Any revisions to electrical equipment required by study.

D. Comments and recommendations for system improvements or revisions in written document, separate from one-line diagram.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600 V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data:

1. One-line diagram of system being studied.
2. Power sources available.
3. Manufacturer, model, and interrupting rating of protective devices.

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4. Conductors.
5. Transformer data.

G. Short-Circuit Study Output Reports:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

   a. Voltage.
   b. Calculated fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. Calculated asymmetrical fault currents:

      1) Based on fault-point X/R ratio.
      2) Based on calculated symmetrical value multiplied by 1.6.
      3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. No AC Decrement (NACD) ratio.
   e. Equivalent impedance.
   f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
   g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

PART 3 - EXECUTION

3.1 POWER SYSTEM DATA

A. Obtain data necessary for conduct of study.

1. Verify completeness of data supplied on one-line diagram. Call discrepancies to Architect's attention.
2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.

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B. Gather and tabulate required input data to support short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to amount of detail that is required to be acquired in field. Field data gathering must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:

1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
11. Derating factors.

3.2 SHORT-CIRCUIT STUDY

A. Perform study following general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 5 kA or less.
2. Exclude equipment supplied by single transformer smaller than 75 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

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G. Include ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low-voltage, three-phase ac systems. Also account for fault-current dc decrement to address asymmetrical requirements of interrupting equipment.

H. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.

I. Include in report identification of protective device applied outside its capacity.

END OF SECTION 26 05 73.13

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SECTION 26 05 73.16

COORDINATION STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

a. Study results must be used to determine coordination of series-rated devices.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260573.13 "Short-Circuit Studies" for fault-current studies.
3. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash studies.

1.2 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled. Existing to remain items must remain functional throughout construction period.

B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when abnormal current flow exists and then removes the affected portion of the circuit from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

F. Single-Line Diagram: See "One-Line Diagram."

1.3 ACTION SUBMITTALS

A. Product Data:

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1. For power system analysis software to be used for studies.

B. Coordination Study Report:

1. Submit the following after approval of system protective devices submittals. Submittals must be in digital form.

a. Coordination-study input data, including completed computer program input data sheets.
b. Study and equipment evaluation reports.
c. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
d. Revised one-line diagram, reflecting field investigation results and results of coordination study.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.5 QUALITY ASSURANCE

A. Studies must be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms must comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. ETAP - Digital Twin Platform.
5. EasyPower, LLC (formerly ESA Inc.).
6. Power Analytics, Corporation.
7. SKM Systems Analysis, Inc.

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B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program must be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program must report device settings and ratings of overcurrent protective devices and must demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

E. Computer program must be designed to perform coordination studies or have function, component, or add-on module designed to perform coordination studies.

F. Computer program must be developed under supervision of licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

2.2 COORDINATION STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kVA and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.
6. Revisions to electrical equipment required by study.
7. Study Input Data: As described in "Power System Data" Article.

a. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."

D. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in field. Use manufacturer's data sheets for recording recommended setting of overcurrent protective devices when available.

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a. Phase and Ground Relays:

1) Device tag.
2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
3) Recommendations on improved relaying systems, if applicable.

b. Circuit Breakers:

1) Adjustable pickups and time delays (long time, short time, and ground).
2) Adjustable time-current characteristic.
3) Adjustable instantaneous pickup.
4) Recommendations on improved trip systems, if applicable.

c. Fuses: Show current rating, voltage, and class.

E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for switching schemes and for emergency periods where power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying portion of system covered.
2. Terminate device characteristic curves at point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
3. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:

a. Power utility's overcurrent protective device.
b. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
d. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
e. Cables and conductors damage curves.
f. Ground-fault protective devices.
g. Motor-starting characteristics and motor damage points.
h. Generator short-circuit decrement curve and generator damage point.
i. Largest feeder circuit breaker in each motor-control center and panelboard.

5. Maintain selectivity for tripping currents caused by overloads.
6. Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
7. Provide adequate time margins between device characteristics such that selective operation is achieved.
8. Comments and recommendations for system improvements.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

A. Obtain data necessary for conduct of overcurrent protective device study.

1. Verify completeness of data supplied in one-line diagram on Drawings. Call discrepancies to Architect's attention.
2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.

B. Gather and tabulate required input data to support coordination study. List below is guide. Comply with recommendations in IEEE 551 for amount of detail required to be acquired in field. Field data gathering must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at service.
3. Power sources and ties.
4. Short-circuit current at each system bus (three phase and line to ground).
5. Full-load current of loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Motor horsepower and NEMA MG 1 code letter designation.

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14. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
15. Data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Generator thermal-damage curve.
    e. Ratings, types, and settings of utility company's overcurrent protective devices.
    f. Special overcurrent protective device settings or types stipulated by utility company.
    g. Time-current-characteristic curves of devices indicated to be coordinated.
    h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.
    k. Identify series-rated interrupting devices for condition where available fault current is greater than interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.3 COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. Base study on device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin analysis at service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 5 kA or less.
2. Exclude equipment supplied by single transformer smaller than 75 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:

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1. Device must not operate in response to the following:

    a. Inrush current when first energized.
    b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings must protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands maximum short-circuit current for time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's instructions and to IEEE 242.

K. Include ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low-voltage, three-phase ac systems. Also account for fault-current dc decrement, to address asymmetrical requirements of interrupting equipment.

L. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.

M. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Application of series-rated devices must be recertified, complying with requirements in NFPA 70.
4. Include in report identification of protective device applied outside its capacity.

3.4 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform load-flow and voltage-drop study to determine steady-state loading profile of system. Analyze power system performance two times as follows:

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1. Determine load flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
2. Determine load flow and voltage drop based on 80 percent of design capacity of load buses.
3. Prepare load-flow and voltage-drop analysis and report to show power system components that are overloaded or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.5 MOTOR-STARTING STUDY

A. Perform motor-starting study to analyze transient effect of system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze effects of motor starting on power system stability.

B. Prepare motor-starting study report, noting light flicker for limits proposed by IEEE 141 and voltage sags so as not to affect operation of other utilization equipment on system supplying motor.

3.6 FIELD ADJUSTING

A. Adjust relay and protective device settings according to recommended settings provided by coordination study. Field adjustments must be completed by engineering service division of equipment manufacturer under "Startup and Acceptance Testing" contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting must be by qualified low-voltage electrical testing and inspecting agency.

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for adjustable overcurrent protective devices.

END OF SECTION 26 05 73.16

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SECTION 26 05 73.19

ARC-FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, arc-flash study to determine arc-flash hazard distance and incident energy to which personnel could be exposed during work on or near electrical equipment.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260573.13 "Short-Circuit Studies" for fault-current studies.
3. Section 260573.16 "Coordination Studies" for overcurrent protective device coordination studies.

1.2 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. p.u.: Per unit. The reference unit, established as a calculating convenience, for expressing all power system electrical parameters on a common reference base.

E. SCCR: Short-circuit current rating.

F. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

G. Single-Line Diagram: See "One-Line Diagram."

1.3 ACTION SUBMITTALS

A. Product Data:

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1. For power system analysis software to be used for studies.

B. Study Submittals:

1. Submit the following after approval of system protective devices submittals. Submittals must be in digital form:

a. Arc-flash study input data, including completed computer program input data sheets.
b. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
c. Revised one-line diagram, reflecting field investigation results and results of arc-flash study.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.5 QUALITY ASSURANCE

A. Study must be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms must comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. ETAP - Digital Twin Platform.
5. EasyPower, LLC (formerly ESA Inc.).
6. Power Analytics, Corporation.
7. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

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C. Analytical features of device coordination study computer software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer program must be designed to perform arc-flash analysis or have function, component, or add-on module designed to perform arc-flash analysis.

E. Computer program must be developed under supervision of licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kVA and voltage ratings, including derating factors and environmental conditions.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output Data: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."

F. Protective Device Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."

G. Arc-Flash Study Output Reports:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in report:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

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1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Restricted approach boundary.
6. Limited approach boundary.
7. Working distance.
8. Incident energy.
9. Hazard risk category.
10. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including definition of terms and guide for interpretation of computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce 3.5 by 5 inch self-adhesive equipment label for each work location included in analysis.

B. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Protection boundaries.
    a. Arc-flash boundary.
    b. Restricted approach boundary.
    c. Limited approach boundary.
4. Arc flash PPE category.
5. Required minimum arc rating of PPE in Cal/cm squared.
6. Available incident energy.
7. Working distance.
8. Engineering report number, revision number, and issue date.

C. Labels must be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

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3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies: Perform Short-Circuit and Protective Device Coordination studies prior to starting Arc-Flash Hazard Analysis or obtain results from another source.

1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
2. Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."

C. Calculate maximum and minimum contributions of fault-current size.

1. Maximum calculation must assume maximum contribution from utility and must assume motors to be operating under full-load conditions.
2. Calculate arc-flash energy at 85 percent of maximum short-circuit current in accordance with IEEE 1584 recommendations.
3. Calculate arc-flash energy at 38 percent of maximum short-circuit current in accordance with NFPA 70E recommendations.
4. Calculate arc-flash energy with utility contribution at minimum and assume no motor contribution.

D. Calculate arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.

E. Include low-voltage equipment locations, except equipment fed from transformers smaller than 75 kVA.

F. Calculate limited, restricted, and prohibited approach boundaries for each location.

G. Incident energy calculations must consider accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations must take into account changing current contributions, as sources are interrupted or decremented with time. Fault contribution from motors and generators must be decremented as follows:

1. Fault contribution from induction motors must not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators must be decayed to match actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 p.u. to 3 p.u. after 10 cycles).

H. Arc-flash energy must generally be reported for maximum of line or load side of circuit breaker. However, arc-flash computation must be performed and reported for both line and load side of circuit breaker as follows:

1. When circuit breaker is in separate enclosure.
2. When line terminals of circuit breaker are separate from work location.

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I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

A. Obtain data necessary for conduct of arc-flash hazard analysis.

1. Verify completeness of data supplied on one-line diagram on Drawings and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article. Call discrepancies to Architect's attention.
2. For new equipment, use characteristics from approved submittals under provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys conducted by qualified technicians and engineers.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to amount of detail that is required to be acquired in field. Field data gathering must be under direct supervision and control of engineer in charge of performing study, and must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance or available short circuit current at service.
3. Power sources and ties.
4. Short-circuit current at each system bus (three phase and line to ground).
5. Full-load current of loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Busway manufacturer and model designation, current rating, impedance, lengths, size, and conductor material.
13. Motor horsepower and NEMA MG 1 code letter designation.
14. Low-voltage conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

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3.4 LABELING

A. Apply one arc-flash label on front cover of each section of equipment and hinged doors or removable plates for each equipment included in study. Base arc-flash label data on highest values calculated at each location.

B. Each piece of equipment listed below not fed by single transformer smaller than 75 kVA must have arc-flash label applied to it:

1. Low-voltage switchgear.
2. Switchboards.
3. Panelboards.
4. Low voltage transformers.
5. Safety switches.
6. Control panels.

C. Note on record Drawings location of equipment where personnel could be exposed to arc-flash hazard during their work.

1. Indicate arc-flash energy.
2. Indicate protection level required.

3.5 APPLICATION OF WARNING LABELS

A. Install arc-flash warning labels under direct supervision and control of qualified electrical professional engineer.

END OF SECTION 26 05 73.19

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SECTION 26 08 00

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including General and Supplementary Conditions and other Division 1 specification sections apply to this section.

B. ASHRAE Standard 202

C. Commissioning Plan

D. Related Sections

1. Section 01 33 00 Submittal Procedures
2. Section 01 42 00 References
3. Section 01 78 23 Operations and Maintenance Data
4. Section 01 78 39 Project Record Documents
5. Section 01 79 00 Demonstration and Training
6. Section 01 91 13 General Commissioning Requirements
7. Division 22 requirements for work in those Sections
8. Section 22 08 00 Commissioning of Plumbing Systems
9. Division 23 requirements for work in those Sections
10. Section 23 08 00 Commissioning of Mechanical Systems
11. Section 26 08 00 Commissioning of Electrical Systems
12. Division 28 requirements for work in those sections

1.2 SUMMARY

A. Section includes commissioning process requirements for Electrical systems, assemblies, and equipment.

B. The commissioning process does not remove or reduce the responsibility of the contractor to provide a finished and fully functioning product. Commissioning should not add to the overall work effort. Commissioning puts a focus on following standard installation and startup procedures, documenting them, resolving issues in a timely manner, verifying the Owner's Project Requirements through equipment, system and integrated system testing, to permit a smooth turnover and acceptance at the end of the project.

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1.3 DESCRIPTION

A. Commissioning: Commissioning is a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meet defined objectives and criteria. The Commissioning process begins at project inception (during the pre-design phase) and continues through the life of the facility. The commissioning process includes specific tasks to be conducted during each phase in order to verify that design, construction, and training meets the owner's project requirements.

B. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:

1. Verify that applicable equipment and systems are installed according to the contract documents, manufacturer's recommendations, and industry accepted minimum standards and those they receive adequate operational checkout by installing contractors.
2. Verify and document proper performance of equipment and systems.
3. Verify that O&M documentation left on site is complete.
4. Verify that the owner's operating personnel are adequately trained.

1.4 COORDINATION

A. Coordinate all sub-trades, other divisions, manufacturers, suppliers, and other specialists as required to ensure all phases of work shall be properly organized prior to commencement of each particular startup, testing and commissioning procedure.

B. Coordinate the activities of this Section with the Commissioning requirements of:

1. Division 1
2. Division 21
3. Division 22
4. Division 23
5. Division 25
6. Division 26
7. Other equipment and systems testing specified in this and other Divisions.

C. Where any equipment or systems require testing prior to starting, ensure that such work has been completed and approved prior to starting of the equipment and or systems.

1.5 RESPONSIBILITIES

A. The Electrical Commissioning process for the vendors/subcontractors consists of:

1. Facilitate the coordination of commissioning and provide to the General Contractor (GC) commissioning activities for incorporation into the Overall Project Schedule (OPS).
2. Provide detailed startup procedures.
3. Include the cost of commissioning in the total contract price.
4. Ensure that all subcontractors and vendors execute their commissioning responsibilities according to the contract documents and the OPS.

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5. Provide copies of all submittals as required in Section 01 33 00 including all changes thereto.
6. Attend and participate in commissioning team meetings held as necessary throughout the construction and acceptance phases.
7. Provide the training of owner personnel.
8. Review and perform Pre-Functional Checklists (PFC) provided by the CxP.
9. Provide test reports as required by Division 21, 22, 23, and 26 to the CxP for review.
10. Cooperate with the CxP for resolution of issues recorded in the Issues Log.
11. Perform work associated with deficiencies identified on the Issues Log and during Functional Performance Testing.
12. Prepare O&M manuals, according to the contract documents, including clarifying and updating the original sequences of operation to as-built/as-tested conditions.
13. Provide assistance for seasonal or deferred performance testing.
14. Ensure that subcontractors correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
15. Perform all guarantees work for materials furnished under the contract for the time specified in the contract, including all warranties, and curing all latent defects within the time period provided in the contract.

1.6 SUBMITTALS

A. Refer also to Specification Section 01 91 13, Subsection 1.8.

B. Provide the CxP a copy of the following items, for the systems to be commissioned:

1. Equipment and System Submittals to include, at a minimum, the following:

   a) Cut sheets
   b) Performance data

2. Manufacturer's pre-startup checklists

   a) Manufacturer's start-up checklist

3. Installation Instructions
4. Shop Drawings (including any resubmittals required by the A/E)
5. Short-circuit analysis and coordination study.
6. Protective device settings
7. Testing plan
8. Completed field test report, including all completed forms and checklists, and list of all outstanding deficiencies and uncompleted items.
9. Operational and maintenance documentation
10. Training plan and training materials
11. As-built documentation

1.7 The electrical systems to be commissioned are listed in the Commissioning Plan with roles and responsibilities listed in Part 3 of 26 08 00.

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PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Provide two-way radios, ladders and other equipment as required to complete the commissioning program as outlined in this specification.

B. Provide all safety equipment required for personnel involved in the Commissioning program.

C. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division.

D. All test and measurement instruments shall have been calibrated within the calendar year prior to testing by an independent metrology laboratory using industry standards and methods.

PART 3 - EXECUTION

3.1 MEETINGS

A. Attend as required by section 01 91 13, Subsection 3.1.

3.2 STARTUP, CONSTRUCTION CHECKLISTS, AND INITIAL CHECKOUT

A. Provide as required by section 01 91 13.

B. The subcontractors and vendors shall execute startup and provide the CxP and A/E, through the owner, with a signed and dated copy of the completed startup and construction checklists.

C. Only individuals of the subcontractor (technicians, engineers, tradesmen, vendors, etc.) who have direct knowledge and witnessed that a line-item task on the construction checklist was actually performed shall check off that item. It is acceptable for witnessing supervisors to fill out these forms.

D. The subcontractor responsible for providing and installing the equipment develops the full start-up plan by combining (or adding to) NETA-ATS with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspection of each procedure and a summary statement with a signature block at the end of the plan.

E. The full start-up plan shall consist of:

1. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
2. NETA Testing Procedure Checklists.
3. The manufacturer's normally used field checkout sheets

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F. The contractor submits the full startup plan to the CxP for review and approval.

G. The CxP reviews and approves the procedures and the format for documenting them, noting any plans that need to be added.

3.3 FUNCTIONAL PERFORMANCE TESTING

A. Provide as required by section 01 91 13.

B. All subcontractor and manufacturer startup and proving tests are to be completed and approved prior to conducting the defined Functional Performance Tests.

C. All associated TAB work and TAB verifications related to a given system shall be completed and approved prior to Functional Performance Testing.

D. All associated Building Management System (BMS) work and BMS point verifications related to a given system shall be completed and approved prior to Functional Performance Testing for related equipment and systems.

E. Development of Test Procedures

1. Electrical testing procedures shall be based on NETA-ATS or manufacturer's testing procedures (central inverter). The A/E and Sub(s) shall point out to the CxP any specific problems as related to feasibility, safety, equipment, and warranty protection. CxP will observe testing by manufacturers or installing contractors and obtain test reports for inclusion into the Commissioning Final Report.

F. Demonstration, Verification and Validation

The electrical systems demonstration shall include, at minimum, the following:

1. Normal Power Switchboard and distribution panels 600A and
2. Emergency Generator
3. Transfer switches
4. Fire Alarm System interlocks with Mechanical Systems (in conjunction with Authority Having Jurisdiction inspection)
5. Fire Pump
6. Demonstrate that all functions of the lighting and daylighting control systems meet the specified requirements. A maximum of 20% of devices will be validated by the CxP.

3.4 DEFICIENCIES AND NON-CONFORMANCE

A. Provide as required by section 01 91 13.

3.5 DEFERRED TESTING

A. Provide as required by section 01 91 13.

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3.6 TRAINING OF OWNER PERSONNEL

A. Provide training for hardware and major components as specified within Section 01 91 13, 01 79 00, Divisions 22, 23, 26, and in the Commissioning Plan.

B. Coordinate operation and maintenance training activities through the GC.

C. The subcontractor and manufacturers shall provide training. The training sessions provided by the subcontractor shall be customized for this project and reflect all the installed equipment and systems. Training of the materials, components, systems, and equipment shall, at the minimum, incorporate the following items:

1. Materials, components, systems, and equipment
2. Safety precautions and procedures
3. Installation
4. Operational features and functions
5. Operational testing and diagnostics
6. Preventive and predictive maintenance
7. Service: Repair and replacement
8. Operation and Maintenance manual content
9. Testing, adjusting, calibration and balancing.
10. Contractor furnished spare parts and extra materials.
11. Recommended “attic stock” inventory not furnished by contractor.
12. Specialty tool requirements
13. Identification systems
14. Automatic/manual control systems
15. Hazards/Material Safety Data Sheets
16. Cleaning
17. Procurement of replacement parts
18. Warranty reviews including terms and conditions, points of contact, return material procedures, effective date, extended warranty options.
19. Maintenance agreements and similar continuing commitments
20. Reference specification section 01 79 00 for specific requirements.

D. No later than two (2) months following acceptance of equipment and system submittals, the responsible Contractor will submit written training plans to the CxP and Owner for review and approval. There shall be one training plan for each specification section requiring training.

E. Provide Training Plans for all equipment as required in the Division 26 contract specifications.

F. Submit the roster and the completed training plans to the CxP through the GC no later than one (1) week following acceptable completion of the training session.

3.7 OPERATIONS AND MAINTENANCE MANUALS

A. Provide operations and maintenance manuals for hardware and major components as specified within Section 01 78 23, 01 91 13, Divisions 22, 23, 26, and in the Commissioning Plan.

B. Coordinate operation and maintenance submittals through the GC.

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C. CxP Review and Approval. Prior to substantial completion, the CxP shall review the operations and maintenance manuals, documentation and redline as-builts for systems that were commissioned to verify compliance with the specifications. The CxP will communicate deficiencies in the manuals to the owner. This work does not supersede the A/E team's review of the operations and maintenance manuals according to the A/E contract.

END OF SECTION 26 08 00

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SECTION 26 09 13

ELECTRICAL POWER MONITORING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Multifunction energy meters.
2. Power meters.
3. Monitoring and control of power distribution equipment.
4. System operator interfaces.
5. Raceways and boxes.
6. Wires and cables.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 262713 "Electricity Metering" for equipment to meter electricity consumption and demand for tenant submetering.

1.2 DEFINITIONS

A. Active Power: The average power consumed by a unit. Also known as "real power."

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. Apparent (Phasor) Power: "S = VI" where "S" is the apparent power, "V" is the RMS value of the voltage, and "I" is the RMS value of the current.

D. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

E. KY Pulse: A method of measuring consumption of electricity that is based on a relay operating like a SPST switch.

F. KYZ Pulse: A method of measuring consumption of electricity based on a relay operating like a SPDT switch.

G. L-G: Line to ground.

H. L-L: Line to line.

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I. L-N: Line to neutral.

J. MODBUS TCP/IP: An open protocol for exchange of process data.

K. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

L. N-G: Neutral to ground.

M. Power Factor: The ratio of active power to apparent power, sometimes expressed in percentage.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Multifunction energy meters.
2. Power meters.
3. Monitoring and control of power distribution equipment.
4. System operator interfaces.
5. Raceways and boxes.
6. Wires and cables.

B. Shop Drawings: For power monitoring and control equipment.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.

a. Attach copies of approved Product Data submittals for products (such as switchboards, switchgear, and motor-control centers) that describe the following:

1) Location of the meters and gateways, and routing of the connecting wiring.
2) Details of power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.

3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
4. Network naming and numbering scheme.
5. Include diagrams for power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
6. Specifications for workstations.
7. Surge Suppressors: Data for each device used and where applied.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

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B. Design Data:

1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format on compact disk or portable storage device with a USB interface.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for the system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to do the following:

1) Design and install new points, panels, and other hardware.
2) Perform preventive maintenance and calibration.
3) Debug hardware problems.
4) Repair or replace hardware.

h. Documentation of programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and database on compact disk or portable storage device with a USB interface.
j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
k. Complete original-issue copies of furnished software, including operating systems, custom programming language, workstation software, and graphics software on compact disk or portable storage device with a USB interface.
l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
m. Owner training materials.

1.5 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.

1. Match components and interconnections for optimum performance of specified functions.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

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PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control of electrical power distribution system(s) that includes the following:

1. Electrical meters that monitor and control.

B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with UL 61010-1 and marked for intended location and application.

2.2 PERFORMANCE REQUIREMENTS

A. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.

1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits."
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.

B. Addressable Devices: Transmitters and receivers must communicate unique device identification and status reports to monitoring and control clients.

C. Backup Power Source:

1. Electrical power distribution equipment served by a backup power source for controls must have associated power monitoring and control system products that monitor and control such systems and equipment also served from a backup power source.

2.3 MULTIFUNCTION ENERGY METERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Schneider Electric USA, Inc. (Basis of Design)
2. Eaton.
3. GE Power; General Electric Company.

B. Multifunction Energy Meter: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power and energy metering and monitoring; complying with UL 61010-1.

1. Capable of metering four-wire wye, three-wire wye, three-wire delta, and single-phase power systems.

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2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.

C. Comply with IEC 60529 degree of protection code of IP65 for the front of the meter, and code of IP30 for the body.

D. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

E. Accuracy:

1. Comply with ANSI C12.20, Class 0.5.
2. Neutral Current Measurement: Not more than 0.65 percent.
3. Power Factor: 1.0 percent.
4. Frequency: 0.1 percent.
5. THD: 1.0 percent.
6. Waveform Sampling: 64 per cycle.

F. Data Link:

1. MODBUS TIA-485, RTU protocol, 4-wire connection to host devices with a compatible port.

G. Meter Physical Characteristics:

1. Display: Backlit LCD with antiglare and scratch-resistant lens.
2. Display of Metered Values:

a. One screen to show at least three user-selected values displayed at the same time. Selections available to display must include the following:

1) Meters.
2) Measurements.
3) THD.
4) Energy.
5) Demand.
6) Minimum and maximum values.
7) Power demand.

H. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 64 samples per cycle, simultaneously on voltage and current channels of the meter.

I. Meters:

1. Instantaneous, RMS:

a. Current: Each phase, neutral and three-phase average.
b. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
c. Active Power (kW): Each phase and three-phase total.
d. Reactive Power (kVAR): Each phase and three-phase total.
e. Apparent Power (kVA): Each phase and three-phase total.

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f. Power Factor: Each phase and three-phase total.

2. Energy:

a. Active Energy (kWh): Three-phase total.

3. Demand, Derived from Instantaneous RMS Meters:

a. Current: Present and maximum.
b. Active: Present and maximum.
c. Reactive: Present and maximum.
d. Apparent: Present and maximum.

4. Power Quality Measurements:

a. THD: Current and voltage from measurements simultaneously from the same cycle, as can be calculated from the specified sampling rate.

J. I/O: Two optically isolated digital outputs for KY pulsing or control. Output signal characteristics must be 150 mA at 200 V.

1. KY Pulse: Generate standard KY pulses for a user-defined increment of metered active energy as follows:

a. User-defined pulse output, associated with kWh.
b. User-defined pulse output, associated with kVARh.

K. Capacities and Characteristics:

1. Power Supply: 120 V(ac), 60 Hz.
2. Circuit Connections:

a. Voltage: Measurement autoranging, 60 to 400 V(ac) L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Meter impedance must be 2 megohm L-L or greater. Overload Tolerance: 1500 V(ac), RMS, continuously.
b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument must be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
c. Frequency: 45 to 65 Hz.
d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.4 POWER METERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Schneider Electric USA, Inc. (Basis of Design)
2. Eaton.

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3. GE Power; General Electric Company.
4. Siemens Industry, Inc., Energy Management Division.

B. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1.

1. Capable of metering four-wire wye, three-wire wye, three-wire delta, and single-phase power systems.
2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.

C. Comply with IEC 60529 degree of protection code of IP51 for the front of the meter, and code of IP30 for the body.

D. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

E. Accuracy:

1. Comply with ANSI C12.20, Class 0.5.
2. Neutral Current Measurement: Not more than 0.65 percent.
3. Power: 0.6 percent.
4. Power Factor: 0.5 percent.
5. Active Energy: 0.6 percent.
6. Reactive Energy: 2.5 percent.
7. Frequency: 0.05 percent.
8. THD: 1.0 percent.
9. Waveform Sampling: 32 per cycle.

F. Data Link:

1. MODBUS TIA-485 RTU protocol, 4-wire connection.

a. Provide for firmware and software updates through the communications port.

G. Meter Physical Characteristics:

1. Display: Backlit LCD with antiglare and scratch-resistant lens.
2. Display of Metered Values: One screen to show at least four> lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values. The screen selections available at the display must include the following:

a. Meters, including those listed under the following:

1) Measurements.
2) THD.
3) Energy.
4) Demand.
5) Minimum and maximum values.
6) Power demand.

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H. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 32 samples per cycle, simultaneously on voltage and current channels of the meter.

I. Meters:

1. Measurements: Instantaneous, in real time, RMS to the 15th harmonic.

   a. Voltage: L-L each phase, L-N each phase, and three-phase average.
   b. Current: Each phase, three-phase average, and neutral.
   c. Unbalanced current, L-L V(ac) and L-N V(ac).
   d. Active Power (+/- kW): Each phase and three-phase total.
   e. Reactive Power (+/- kVAR): Each phase and three-phase total.
   f. Apparent Power (+/- kVA): Each phase and three-phase total.
   g. Displacement Power Factor: Each phase and three-phase total.
   h. Distortion Power Factor: Each phase and three-phase total.
   i. Frequency.

2. THD from measurements simultaneously from the same cycle, through 15th harmonic.

   a. Voltage THD: L-L each phase, L-N each phase, and three-phase average.
   b. Current THD: Each phase and three-phase average.
   c. Total demand distortion.

3. Energy: Accumulated, indicate whether in-flow or out-flow, net and absolute values. Store the values in instrument's nonvolatile memory.

   a. Active kWh.
   b. Reactive kVARh.
   c. Apparent kVAh.

4. Demand: Present, last, predicted, peak.

   a. Three-phase average current.
   b. Three-phase total active power (kW).
   c. Reactive power (kVAR).
   d. Apparent power (kVA).

5. Minimum and Maximum Values:

   a. L-L and L-N voltages.
   b. Current in each phase.
   c. Power factor.
   d. Active power total.
   e. Reactive power total.
   f. Apparent power total.
   g. THD L-L and L-N voltages.
   h. THD current in each phase.
   i. Frequency.

J. Power Demand, User Selectable:

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1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:

    a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
    b. Fixed block that calculates demand at end of the interval.
    c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.

3. Demand Calculation Initiated by a Synchronization Signal:

    a. Signal is a pulse from an external source. Demand period begins with every pulse. Calculation must be configurable as either a block or rolling block calculation.
    b. Signal is a communication signal. Calculation must be configurable as either a block or rolling block calculation.
    c. Provide for synchronizing the demand with the internal of this instrument.

K. Data Recording: Store the listed values in instrument's nonvolatile memory, indicate which of the three phases relates to the value. Attach a date and time stamp to the peak values and the alarms.

1. Minimum and maximum of real-time RMS measurement.
2. Energy.
3. Demand values.
4. Alarms, store the last 40 events.

L. Alarms: Transmit a digital output and show on display when alarmed. Provide for no fewer than 15 metered items. Each alarm must be user configured, by using the following options:

1. Date and time stamp.
2. Enable-disable (default) or enable.
3. Pickup magnitude.
4. Pickup time delay.
5. Dropout magnitude.
6. Dropout time delay.
7. Alarm type.
8. Alarm label.

M. Output Signals: Provide two mechanical relays, rated not less than 250 V(ac), 2 A resistive, and rated for 200,000 cycles or more. The relays must be user configurable in one of the following listed modes:

1. Normal contact closure where the contacts change state for as long as the signal exists.
2. Latched mode when the contacts change state when a pickup signal is received and are held until a dropout signal is received.
3. Timed mode when the contacts change state when a pickup signal is received and are held for a preprogrammed duration.

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N. Meter Face:

1. Display: Backlit LCD display, six lines, with antiglare and scratch-resistant lens.
2. Display of Metered Values: One screen to show at least four user-selected values on one screen at the same time.
3. Provide for the reset of metered peak values.

O. Capacities and Characteristics:

1. Power Supply: 120 V(ac), 60 Hz.
2. Circuit Connections:

   a. Voltage: Measurements autoranging, 60 to 400 V(ac) L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Meter impedance must be 2 megohm L-L or greater. Overload Tolerance: 1500 V(ac), RMS, continuously.
   b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument must be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
   c. Frequency: 45 to 65 Hz.
   d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.5 MONITORING AND CONTROL OF POWER DISTRIBUTION EQUIPMENT

A. Power Distribution Equipment: Web-enabled, direct connected to the LAN or intranet.

B. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

C. Ethernet Connectivity:

1. A multipoint, MODBUS TIA-485 serial communications network must be included within the equipment to interconnect breaker trip units, protective relays, drives, and metering devices equipped with communications.
2. Serial communications network must be wired to an Ethernet server in the incoming section of the equipment. Hardware and cabling required for the connection to the network must be included within the power distribution equipment.
3. Serial communications devices within the equipment must be factory addressed and tested to verify reliable communications to the equipment's Ethernet Server.

D. Ethernet Gateways:

1. User configurable; complying with UL 60950-1, and IEEE 802.3, Class 3 PoE.

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2. Include provisions to set initial Ethernet parameters via a local operator interface, or standard (8PSJ) Ethernet port, that is accessible from the front of the equipment. Initial setup must be limited to basic Ethernet addressing parameters, as assigned by Owner.
3. Common Gateway Features:

    a. User configurable, with secure password-protected login process.
    b. Include communications diagnostic information for serial and Ethernet ports as well as internal health status and memory management information through embedded HTML web pages for viewing using a standard web browser.
    c. Include embedded HTML pages providing real-time information from devices connected to the Ethernet gateway's TIA-485 port(s) through a standard web browser.
    d. Allow firmware upgrades through the communications port.

4. Include a "Quick-Start" guide with the equipment to describe the commissioning process for setting the equipment's Ethernet network address and for ensuring trouble-free data access from any PC on the network, using a standard web browser.
5. Implement a common user interface ("look and feel") across different styles of power equipment.

E. Distribution Equipment Monitoring:

1. Main menu and summary pages, factory configured, to display data for each communicating device within the power equipment lineup.
2. Display Data:

    a. Circuit summary page to display circuit name, three-phase average RMS current, real power (kW), power factor, and breaker status (if applicable).
    b. Load current summary page to display circuit name, and phase a, b, and c RMS current values.
    c. Demand current summary page to display circuit name, and phase a, b, and c average demand current values.
    d. Power summary page to display circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
    e. Energy summary page to display circuit name, real energy (kWh), reactive energy (kVARh), and time/date of last reset.
    f. For unit substations equipped with dry-type transformer(s) and microbased temperature controller(s), the circuit summary web page listed above must be augmented with transformer coil temperatures, phase a, b and c current values, and cooling fan status (on/off).
    g. For motor-control centers, the circuit summary web page must be tailored specifically for this application, to display circuit name, three-phase average RMS current, thermal capacity (percentage), drive output frequency (in Hertz, where applicable), and contactor status.

2.6 SYSTEM OPERATOR INTERFACES

A. Operator means of system access must be through the following:

1. Portable terminal with hardwired connection through LAN port at each meter.

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2.7 RACEWAYS AND BOXES

A. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" for raceways for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

2.8 WIRES AND CABLES

A. Electrical Power Wiring: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Copper conductors are Type THHN/THWN-2.

B. Control Wiring: Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

1. Optical-Fiber Cable: Multimode, 50/125 micrometer OM3, six-fiber, nonconductive, tight-buffer, optical-fiber cable, with aqua jacket.
2. Balanced Twisted Pair Cable: 100 ohm, four-pair Category 6.
3. Workstation Outlets: Four-port-connector assemblies mounted in single or multigang faceplate. Coordinate color and labels with Section 262726 "Wiring Devices."
4. TIA-485 Cable: Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
5. Control-Voltage Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.

a. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
b. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
c. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.

C. TIA-232 Cable:

1. PVC-Jacketed, TIA-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; PVC jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

a. Type CM.
b. Flame Resistance: UL 1581, vertical tray.

2. Plenum-Type, TIA-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

a. Type CMP.
b. Flame Resistance: NFPA 262, flame test.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF POWER MONITORING AND CONTROL SYSTEMS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

C. Wiring and Cabling Installation:

1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
2. Comply with Section 260523 "Control-Voltage Electrical Power Cables" for control wiring.

D. Raceways Installation:

1. Comply with Section 260533.13 "Conduits for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

E. Identification Installation:

1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.

3.3 GROUNDING

A. For data communication wiring, comply with BICSI N1.

B. For control-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by authorities having jurisdiction.

B. Tests and Inspections:

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1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Visually inspect balanced twisted pair cabling and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA-568-C.1.
3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of components.
4. Test balanced twisted pair cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.

    a. Test instruments must meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.

5. Optical-Fiber Cable Tests:

    a. Test instruments must meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to IEC 61280-4-1.
        2) Attenuation test results for links must be less than 2.0 dB.

    c. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.

6. Power Monitoring and Control System Tests.

    a. Test Analog Signals:

        1) Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
        2) Check analog current signals using a precision current meter at zero, 50, and 100 percent.
        3) Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

    b. Test Digital Signals:

        1) Check digital signals using a jumper wire.

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2) Check digital signals using an ohmmeter to test for contact making or breaking.

c. I/O Control Loop Tests:

1) Test every I/O point to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2) Test every I/O point throughout its full operating range.
3) Test every control loop to verify that operation is stable and accurate.
4) Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5) Test and adjust every control loop for proper operation according to sequence of operation.
6) Test software and hardware interlocks for proper operation.
7) Operate each analog point at the following:

a) Upper quarter of range.
b) Lower quarter of range.
c) At midpoint of range.

8) Exercise each binary point.
9) For every I/O point in the system, read and record each value at workstation, at controller, and at field instrument simultaneously. Value displayed at workstation and at field instrument must match.
10) Prepare and submit a report documenting results for each I/O point in the system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

C. Nonconforming Work:

1. Wiring and cabling will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 FINAL REVIEW

A. Submit written request to Architect, Engineer, and Construction Manager when the power monitoring and control system is ready for final review. Written request must state the following:

1. The system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
2. The system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
3. The system monitoring and control of electrical distribution systems results in operation according to sequences of operation indicated.

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4. The system is complete and ready for final review.

B. Review by Architect, Engineer, and Construction Manager will be made after receipt of written request. A field report must be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Final review must include a demonstration to parties participating in final review.

3.6 MAINTENANCE SERVICE

A. Beginning at Substantial Completion, maintenance service must include 12 months' full maintenance by manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of defective components, cleaning, and adjusting as required for proper system operation. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

3.7 TRAINING

A. Attendee Training Manuals:

1. Provide each attendee with a color hard copy of training materials and visual presentations.
2. Hard-copy materials must be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of hard-copy materials.

B. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
2. Instructor must provide training materials, projector, and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training must include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
5. The workstation provided with the system must be used in training. If workstation is not indicated, provide a temporary workstation to convey training content.

C. At Completion of Training: Staff familiar with the system installed are capable of demonstrating operation of the system during final review.

D. Demonstration must include, but not be limited to, the following:

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1. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
2. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and workstations.
3. Trends, summaries, logs, and reports set-up for Project.
4. Software's ability to communicate with controllers and uploading and downloading of control programs.
5. Data entry to show Project-specific customizing capability including parameter changes.
6. Step through penetration tree, display graphics, demonstrate dynamic update, and direct access to graphics.
7. Execution of digital and analog commands in graphic mode.
8. Spreadsheet and curve plot software and its integration with database.
9. Online user guide and help functions.
10. For Each Meter:

    a. Memory: Programmed data, parameters, trend, and alarm history collected during normal operation is not lost during power failure.
    b. Operator Interface: Ability to connect directly to each meter with a portable workstation.
    c. Wiring Labels: Match control drawings.
    d. Network Communication: Ability to locate a meter on the network. Communication architecture matches Shop Drawings.
    e. Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.

END OF SECTION 26 09 13

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SECTION 26 09 23

LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electronic dial-time switches.
2. Electromechanical dial-time switches.
3. Outdoor photoelectric switches, solid state, flexible mounting.
4. Outdoor photoelectric switches, solid state, luminaire-mounted.
5. Outdoor photoelectric switches, low voltage.
6. Daylight-harvesting switching controls.
7. Daylight-harvesting dimming controls, digital.
8. Indoor occupancy and vacancy sensors.
9. Lighting contactors.
10. Emergency shunt relay.
11. Conductors and cables.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Electronic dial-time switches.
2. Electromechanical dial-time switches.
3. Outdoor photoelectric switches, solid state, flexible mounting.
4. Outdoor photoelectric switches, solid state, luminaire-mounted.
5. Outdoor photoelectric switches, low voltage.
6. Daylight-harvesting switching controls.
7. Daylight-harvesting dimming controls, digital.
8. Indoor occupancy and vacancy sensors.
9. Lighting contactors.
10. Emergency shunt relay.
11. Conductors and cables.

B. Shop Drawings:

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1. Show installation details for the following:

    a. Occupancy sensors.
    b. Vacancy sensors.

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For manufacturer's warranties.

1.4 WARRANTY

A. Special Extended Warranty: Manufacturer and Installer warrant that installed lighting control devices perform in accordance with specified requirements and agree to repair or replace, including labor, materials, and equipment, devices that fail to perform as specified within extended warranty period.

1. Failures include, but are not limited to, the following:

    a. Faulty operation of lighting control software.
    b. Faulty operation of lighting control devices.

2. Extended Warranty Period: Two (2) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ELECTRONIC TIME SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. NSi Industries LLC. (Basis of Design)
2. Eaton.
3. Intermatic, Inc.
4. Schneider Electric USA, Inc.

B. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Contact Configuration: SPST.
3. Contact Rating: 30 A inductive or resistive, 600 V(ac).

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4. Programs:

   a. Two on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays].

5. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
6. Astronomic Time: All channels.
7. Automatic daylight savings time changeover.
8. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.

2.2 ELECTROMECHANICAL DIAL-TIME SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. NSi Industries LLC. (Basis of Design)
2. Eaton.
3. Intermatic, Inc.
4. Schneider Electric USA, Inc.

B. Electromechanical-Dial Time Switches: Comply with UL 917.

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Contact Configuration: SPST.
3. Contact Rating: 30 A inductive or resistive, 600 V(ac).
4. Circuitry: Allows connection of a photoelectric relay as a substitute for the on-off function of a program.
5. Astronomic time dial.
6. Eight-Day Program: Uniquely programmable for each weekday and holidays.
7. Skip-a-day mode.
8. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.3 OUTDOOR PHOTOELECTRIC SWITCHES, SOLID STATE, FLEXIBLE MOUNTING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. NSi Industries LLC.

2. Eaton.
3. Intermatic, Inc.
4. nLight; Acuity Brands Lighting, Inc.

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B. Description: Solid state, with SPST dry contacts rated for 1800 VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A, and compatible with ballasts and LED lamps.

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
3. Time Delay: Fifteen-second minimum, to prevent false operation.
4. Surge Protection: Metal-oxide varistor.
5. Mounting: Twist lock complies with ANSI C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure from same source and manufacturer as switch.
6. Failure Mode: Luminaire stays ON.

2.4 OUTDOOR PHOTOELECTRIC SWITCHES, SOLID STATE, LUMINAIRE-MOUNTED

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. nLight; Acuity Brands Lighting, Inc.
2. NSi Industries, LLC.
3. Eaton.
4. Intermatic, Inc.

B. Description: Solid state, with SPST dry contacts rated for 1800 VA inductive, to operate connected load, complying with UL 773, and compatible with CFL and LED lamps.

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
3. Time Delay: Thirty-second minimum, to prevent false operation.
4. Lightning Arrester: Air-gap type.
5. Mounting: Twist lock complying with ANSI C136.10, with base from same source and manufacturer as switch.
6. Failure Mode: Luminaire stays ON.

2.5 OUTDOOR PHOTOELECTRIC SWITCHES, LOW VOLTAGE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. NSi Industries LLC.
2. Eaton.
3. Intermatic, Inc.

NOT FOR BIDDING PURPOSES

4. nLight; Acuity Brands Lighting, Inc.

B. Description: Solid state; one set of NO dry contacts rated for 24 V(ac) at 1 A, to operate connected load, complying with UL 773, and compatible with luminaire and power pack.

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
3. Time Delay: Thirty-second minimum, to prevent false operation.
4. Mounting: 1/2 inch threaded male conduit.
5. Failure Mode: Luminaire stays ON.
6. Power Pack:

a. Dry contacts rated for 20 A LED load at 120 and 277 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.

1) LED status lights to indicate load status.
2) Plenum rated.

b. Digital controller capable of accepting four 8PSJ inputs with two outputs rated for 20 A LED at 120 and 277 V(ac). Sensor has 24 V(dc), Class 2 power source.

1) With integral current monitoring.
2) Compatible with digital addressable lighting interface.
3) Plenum rated.

2.6 DAYLIGHT-HARVESTING SWITCHING CONTROLS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. nLight; Acuity Brands Lighting, Inc. (Basis of Design)
2. Lithonia Lighting; Acuity Brands Lighting, Inc.
3. Sensor Switch, Inc.
4. WattStopper; Legrand North America, LLC.

B. Description: System operates indoor lighting.

C. Sequence of Operation: As daylight increases, the lights are turned off at a predetermined level. As daylight decreases, the lights are turned on at a predetermined level.

1. Lighting control set point is based on two lighting conditions:

a. When no daylight is present.
b. When significant daylight is present (target level).
c. System programming is done with two hand-held, remote-control tools.

D. Ceiling-Mounted Switching Controls:

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1. Solid-state, light-level sensor unit, with separate power pack, that detects changes in indoor lighting levels that are perceived by the eye.

E. Electrical Components, Devices, and Accessories:

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
3. Sensor Output:

    a. Contacts rated to operate the associated power pack, complying with UL 773A. Sensor must be powered by the power pack.

4. Sensor type: Open loop.
5. Zone: Single.
6. Power Pack:

    a. Dry contacts rated for 20 A LED load at 120- and 277 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.

        1) LED status lights to indicate load status.
        2) Plenum rated.

    b. Digital controller capable of accepting four 8PSJ inputs with two outputs rated for 20 A LED load at 120 and 277 V(ac). Sensor has 24 V(dc) Class 2 power source.

        1) With integral current monitoring
        2) Compatible with digital addressable lighting interface.
        3) Plenum rated.

7. General Space Sensors Light-Level Monitoring Range: 10 to 200 fc, with an adjustment for turn-on and turn-off levels within that range.
8. Atrium Space Sensors Light-Level Monitoring Range: 100 to 1000 fc, with an adjustment for turn-on and turn-off levels within that range.
9. Skylight Sensors Light-Level Monitoring Range: 1000 to 10 000 fc, with an adjustment for turn-on and turn-off levels within that range.
10. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling.
11. Set-Point Adjustment: Equip with deadband adjustment of 25, 50, and 75 percent above the "on" set point, or provide with separate adjustable "on" and "off" set points.
12. Test Mode: User selectable, overriding programmed time delay to allow settings check.
13. Control Load Status: User selectable to confirm that load wiring is correct.
14. Indicator: Two digital displays to indicate the beginning of on-off cycles.

2.7 DAYLIGHT-HARVESTING DIMMING CONTROLS, DIGITAL

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. nLight; Acuity Brands Lighting, Inc. (Basis of Design)

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2. Lithonia Lighting; Acuity Brands Lighting, Inc.
3. WattStopper; Legrand North America, LLC.

B. Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, lights are dimmed.

1. Lighting control set point is based on the following two lighting conditions:

a. When no daylight is present (target level).
b. When significant daylight is present.

2. System programming is done with two hand-held, remote-control tools.

a. Initial setup tool.
b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with separate power pack, to detect changes in indoor lighting levels that are perceived by the eye.

D. Electrical Components, Devices, and Accessories:

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Sensor Output: zero to 10 V(dc) to operate luminaires. Sensor is powered by controller unit.
3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc.

E. Power Pack: Digital controller capable of accepting four 8PSJ inputs with two output(s) rated for 20 A LED at 120 and 277 V(ac). Sensor has 24 V(dc) Class 2 power source.

1. With integral current monitoring.
2. Compatible with digital addressable lighting interface.
3. Plenum rated.

2.8 INDOOR OCCUPANCY AND VACANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. nLight; Acuity Brands Lighting, Inc. (Basis of Design)
2. Lithonia Lighting; Acuity Brands Lighting, Inc.
3. Lutron Electronics Co., Inc.
4. Sensor Switch, Inc.
5. WattStopper; Legrand North America, LLC.

B. General Requirements for Sensors:

1. Wall or Ceiling mounted as indicated on drawings, solid-state indoor occupancy/vacancy sensors.

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2. Passive infrared and Ultrasonic Dual technology.
3. Separate power pack.
4. Hardwired connection to switch.
5. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
6. Operation:

    a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
8. Power: Line voltage.
9. Power Pack: Dry contacts rated for 20 A LED load at 120 and 277 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
10. Mounting:

    a. Sensor: Suitable for mounting in any position in a standard device box or outlet box.
    b. Relay: Externally mounted through a 1/2 inch knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. PIR Type: Wall or Ceiling mounted as indicated on drawings; detect occupants in coverage area by their heat and movement.

1. Detector Sensitivity: Detect occurrences of 6 inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch.
2. Detection Coverage (Room, Ceiling Mounted): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96 inch high ceiling.
3. Detection Coverage (Corridor, Ceiling Mounted): Detect occupancy within 90 ft. when mounted on a 10 ft. high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 sq. ft. when mounted 48 inch above finished floor.

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D. Ultrasonic Type: Wall or Ceiling mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inch in either a horizontal or a vertical manner at an approximate speed of 12 inch/s.
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96 inch high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96 inch high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96 inch high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 ft. when mounted on a 10 ft. high ceiling in a corridor not wider than 14 ft.
6. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 sq. ft. when mounted 84 inch above finished floor.

E. Dual-Technology Type: Wall or Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6 inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch, and detect a person of average size and weight moving not less than 12 inch in either a horizontal or a vertical manner at an approximate speed of 12 inch/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96 inch high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 sq. ft. when mounted 48 inch above finished floor.

2.9 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; Schneider Electric USA. (Basis of Design)
2. ASCO Power Technologies.
3. Eaton.

B. Description: Electrically operated and electrically held, combination-type lighting contactors with fusible switch, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less THD of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.

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4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.10 EMERGENCY SHUNT RELAY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. nLight; Acuity Brands Lighting, Inc. (Basis of Design)
2. WattStopper; Legrand North America, LLC.

B. Description: NC, electrically held relay, arranged for wiring in parallel with automatic switching contacts; complying with UL 924.

1. Coil Rating: 277 V.

2.11 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SENSORS

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

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B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's instructions.

3.3 INSTALLATION OF CONTACTORS

A. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.4 INSTALLATION OF WIRING

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.

B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.

C. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

3.5 IDENTIFICATION

A. Identify components and power and control wiring in accordance with Section 260553 "Identification for Electrical Systems.

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.6 FIELD QUALITY CONTROL

A. Field tests must be witnessed by authorities having jurisdiction.

B. Tests and Inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Nonconforming Work:

NOT FOR BIDDING PURPOSES

1. Lighting control devices will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Prepare test and inspection reports.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections as required.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.8 MAINTENANCE

A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software support for two years.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Verify upgrading software includes operating system and new or revised licenses for using software.

a. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3. Upgrade Reports: Prepare written report after each update, documenting upgrades installed.

END OF SECTION 26 09 23

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SECTION 26 09 36

MODULAR DIMMING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wall-box multiscene dimming controls.
2. Conductors and cables.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 DEFINITIONS

A. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.

B. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.

C. SCR: Silicon-controlled rectifier.

D. Zone: A luminaire or group of luminaires controlled simultaneously as a single entity. Also known as a "channel."

1.3 ACTION SUBMITTALS

A. Product Data:

1. Wall-box multiscene dimming controls.
2. Conductors and cables.

B. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.

1. Include elevation views of front panels of control and indicating devices and control stations.
2. Include diagrams for power, signal, and control wiring.

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3. Address Drawing: Reflected ceiling plan and floor plans, showing connected luminaires, address for each luminaire, and luminaire groups. Base plans on construction plans, using the same legend, symbols, and schedules.
4. Point List and Data Bus Load: Summary list of control devices, sensors, ballasts, and other loads. Include percentage of rated connected load and device addresses.
5. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.
6. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.5 WARRANTY

A. Special Manufacturer Extended Warranty: Manufacturer warrants that components of modular dimming controls perform in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended warranty period.

1. Initial Extended Warranty Period: Two (2) years from date of Substantial Completion, for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 MODULAR DIMMING CONTROLS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Douglas Lighting Controls.
2. Leviton Manufacturing Co., Inc.
3. Lutron Electronics Co., Inc.
4. Philips; Signify North America; Signify Holding.

2.2 SYSTEM DESCRIPTION

A. Compatibility:

1. Dimming control components must be compatible with luminaires, drivers, and transformers.

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2. Dimming control devices must be compatible with lighting control system components specified in Section 260923 "Lighting Control Devices."

B. Dimmers and Dimmer Modules: Comply with UL 508.

1. Audible Noise and RFI Suppression: Solid-state dimmers must operate smoothly over their operating ranges without audible lamp or dimmer noise or RFI. Modules must include integral or external filters to suppress audible noise and RFI.
2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

C. Capacities: Unit must be rated for 2000 W at 120 V(ac) for up to 100 devices or zones.

D. Surge Protection: Withstand supply power surges without impairment to performance.

1. Panels: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.
2. Other System Devices: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.

E. Off Control Position: User-selected off position of any control point must disconnect the load from line supply.

F. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2.3 WALL-BOX MULTISCENE DIMMING CONTROLS

A. Description: Factory-fabricated equipment providing manual dimming consisting of a wall-box-mounted master controller and indicated number of wall-box zone stations. Controls and dimmers must be integrated for mounting in multigang wall box under a single wall plate. Each zone must be adjustable to indicated number of scenes, which must reside in the memory of zone controller.

B. Dimmers:

1. Each zone must be configurable to control the following loads:

a. LED lamps.

2. Regulate voltages to maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of RMS voltage.

C. Memory:

1. Retain preset scenes and fade rates through momentary (up to 3 s) power interruptions.
2. Retain preset scenes through power failures for at least seven days.

D. Device Cover Plates: Style, material, and color must comply with Section 260533.16 "Boxes and Covers for Electrical Systems". Master-control cover plate must be one piece.

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E. Master controller must include the following:

1. Cover-mounted switches, including master off, all bright, and selectors for each scene.
2. Cover-mounted LED indicator lights, one associated with each scene switch, and one for the master off switch.
3. Concealed switches and indicators for specified function.
4. A raise/lower switch for each zone for temporary adjustments of the zone, without altering scene values stored in memory.
5. Fade time indicated by digital display for current scene while fading.
6. Cover-mounted infrared receiver.

F. Infrared Transmitters: Wireless remote control for recalling each of the presets. Operate up to 50 ft. within line of sight of the master controller.

2.4 CONDUCTORS AND CABLES

A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

PART 3 - EXECUTION

3.1 INSTALLATION OF WIRING

A. Wiring Method: Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables" and Section 260533.13 "Conduits for Electrical Systems."

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.

C. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Label each dimmer module with a unique designation.

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C. Label each scene control button with approved scene description.

3.3 FIELD QUALITY CONTROL

A. Field tests must be witnessed by authorities having jurisdiction.

B. Tests and Inspections:

1. Continuity tests of circuits.
2. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.

a. Include testing of modular dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

C. Nonconforming Work:

1. Dimming control components will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

E. Reports: Prepare written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

F. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

END OF SECTION 26 09 36

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SECTION 26 22 13

LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution, dry-type transformers with nominal primary and secondary rating of 600 V and less, with capacities up to 300 kVA.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.

a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
b. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

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1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation and testing instructions issued to Installer by manufacturer for the following:

1. Transformer temporary heating, working clearances, anchoring, torque values, and insulation-resistance testing.

B. Source quality-control reports.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in warm, dry, and temperature-stable location in original shipping packaging.

C. Temporary Heating: Apply temporary heat in accordance with manufacturer's published instructions within enclosure of ventilated-type units, throughout periods during which equipment is not energized and when transformer is not in space that is continuously under normal control of temperature and humidity.

D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; Schneider Electric USA. (Basis of Design)
2. Eaton.
3. Siemens Industry, Inc., Energy Management Division.
4. ABB, Electrification Business

B. Source Limitations: Obtain each type of transformer from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60 Hz service.

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B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

C. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by qualified electrical testing laboratory recognized by authorities having jurisdiction.

D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.
2. Core volume must allow efficient transformer operation at 10 percent above nominal tap voltage.
3. Grounded to enclosure.

C. Coils: Continuous windings without splices except for taps.

1. Coil Material: Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Bolted.

D. Encapsulation: Transformers smaller than 30 kVA must have core and coils completely resin encapsulated.

E. Enclosure: Ventilated.

1. Core and coil must be encapsulated within resin compound using vacuum-pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
3. Wiring Compartment: Sized for conduit entry and wiring installation.
4. Environmental Protection:

   a. Indoor: UL 50E, Type 2.
   b. Outdoor: UL 50E, Type 3R.

5. Finish Color: Gray weather-resistant enamel.

F. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

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G. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with maximum of 115 deg C rise above 40 deg C ambient temperature.

H. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with maximum of 150 deg C rise above 40 deg C ambient temperature.

I. Grounding: Provide ground-bar kit or ground bar installed on inside of transformer enclosure.

J. Electrostatic Shielding: Windings must have independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding shield.

K. Low-Sound-Level Requirements: Maximum sound levels when factory tested in accordance with IEEE C57.12.91, as follows:

1. 30.01 to 50.00 kVA: 45 dB(A-weighted) for K-factors of 1, 4, and 9; 48 dB(A-weighted) for K-factors of 13 and 20.
2. 50.01 to 150.00 kVA: 50 dB(A-weighted) for K-factors of 1, 4, and 9; 53 dB(A-weighted) for K-factors of 13 and 20.
3. 150.01 to 300.00 kVA: 55 dB(A-weighted) for K-factors of 1, 4, and 9; 58 dB(A-weighted) for K-factors of 13 and 20.

L. All transformers, whether floor or wall mounted, or suspended from the building structure, shall be mounted on Isomode vibration isolator pads. Immediate connections to and from transformer shall be through flexible conduit to avoid transmission of vibration to the conduit system or to the building structure. Complete shop drawings and details of vibration isolation shall be submitted to the Engineer for approval.

2.4 IDENTIFICATION

A. Nameplates:

1. Engraved, laminated-acrylic or melamine plastic signs for distribution transformers, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Testing Administrant: Engage qualified electrical testing agency to evaluate transformer.

B. Nonconforming Work:

1. System equipment that does not pass tests and inspections will be considered defective.

C. Prepare test and inspection reports.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for transformers.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's published instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 Ω at location of transformer.

E. Environment: Enclosures must be rated for environment in which they are located. Covers for UL 50E, Type 4X enclosures may not cause accessibility problems.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install transformers level and plumb on concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

B. Construct concrete bases and anchor floor-mounted transformers in accordance with manufacturer's published instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Secure transformer to concrete base in accordance with manufacturer's published instructions.

D. Secure covers to enclosure and tighten bolts to manufacturer-recommended torques to reduce noise generation.

E. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

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C. Tighten electrical connectors and terminals in accordance with manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at conduit and conductor terminations and supports to eliminate sound and vibration transmission to building structure.

3.4 FIELD QUALITY CONTROL

A. Testing Preparation:

B. Field tests and inspections must be witnessed by authorities having jurisdiction.

C. Tests and Inspections:

1. Small (Up to 167 kVA Single-Phase or 500 kVA Three-Phase) Dry-Type Transformer Field Tests:

a. Visual and Mechanical Inspection.

1) Inspect physical and mechanical condition.
2) Inspect anchorage, alignment, and grounding.
3) Verify that resilient mounts are free and that shipping brackets have been removed.
4) Verify that unit is clean.
5) Perform specific inspections and mechanical tests recommended by manufacturer.
6) Verify that as-left tap connections are as specified.
7) Verify presence of surge arresters and that their ratings are as specified.

b. Electrical Tests:

1) Measure resistance at windings, taps, and bolted connections.
2) Perform insulation-resistance tests winding-to-winding and windings-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: value of index may not be less than 1.0.
3) Perform turns-ratio tests at tap positions. Test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
4) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

D. Test Labeling: On completion of satisfactory testing of units, attach dated and signed "Satisfactory Test" label to tested components.

E. Nonconforming Work:

1. Transformer will be considered defective if it does not pass tests and inspections.

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2. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. Assemble and submit test and inspection reports.

G. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

3.5 ADJUSTING

A. Record transformer secondary voltage at unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.7 MAINTENANCE

A. Infrared Scanning: Two months after Substantial Completion, perform infrared scan of transformer connections.

1. Use infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform two follow-up infrared scans of transformers, one at four months and another at 11 months after Substantial Completion.
3. Prepare certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

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SECTION 26 24 13

SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.

1.3 RELATED SECTIONS

A. Section 260574 "Overcurrent Protective Device Arc-Flash Study" for arc-flash study and arc-flash label requirements.

1.4 ACTION SUBMITTALS

A. Do not submit shop drawings until approved Short Circuit and Coordination Study has been submitted.

B. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.

1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

C. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.

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5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Include evidence of NRTL listing for series rating of installed devices.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
10. Include diagram and details of proposed mimic bus.
11. Include schematic and wiring diagrams for power, signal, and control wiring.

D. Samples: Representative portion of mimic bus with specified material and finish, for color selection.

E. Delegated Design Submittal:

1. For arc-flash hazard study.
2. For arc-flash labels.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Routine maintenance requirements for switchboards and all installed components.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

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1.7 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Handle and prepare switchboards for installation according to NECA 400 and NEMA PB 2.1.

1.9 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 104 deg F.
b. Altitude: Not exceeding 6600 feet.

B. Unusual Service Conditions: NEMA PB 2, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

1.10 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

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1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three (3) years from date of Substantial Completion.

B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; by Schneider Electric. (Basis of Design)
2. Eaton.
3. ABB
4. SIEMENS Industry, Inc.; Energy Management Division.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

I. Nominal System Voltage: 480Y/277 V.

J. Main-Bus Continuous: As indicated on drawings.

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K. Indoor Enclosures: Steel, NEMA 250, Type 1.

L. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

M. Barriers: Between adjacent switchboard sections.

N. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

O. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

P. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

Q. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

R. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

S. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.
3. Copper feeder circuit-breaker line connections.
4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
5. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
6. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
7. Disconnect Links:

    a. Isolate neutral bus from incoming neutral conductors.

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b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.

8. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

T. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; by Schneider Electric. (Basis of Design)
2. Advanced Protection Technologies Inc. (APT).
3. Eaton.
4. ABB
5. SIEMENS Industry, Inc.; Energy Management Division.

B. SPDs: Comply with UL 1449, Type 1.

C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.

D. Features and Accessories:

1. Integral disconnect switch.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Indicator light display for protection status.
4. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
5. Surge counter.

E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

F. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V.
2. Line to Ground: 1200 V for 480Y/277 V.
3. Line to Line: 2000 V for 480Y/277 V.

G. SCCR: Equal or exceed 100 kA.

H. Nominal Rating: 20 kA.

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2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long and short time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
8. MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
    f. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
    g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
    h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
    i. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
    j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

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B. Insulated-Case Circuit Breaker (ICCB): 80 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.

1. Fixed circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Standard-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Time adjustments for long- and short-time pickup.
    c. Ground-fault pickup level, time delay, and I^2t response.

4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Control Voltage: 120-V ac.

C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Schneider Electric USA (Square D). (Basis of Design)
    b. Eaton.
    c. SIEMENS Industry, Inc.; Energy Management Division.

2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.

3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.

    a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
    b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.

4. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
5. Service-Rated Switches: Labeled for use as service equipment.
6. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

NOT FOR BIDDING PURPOSES

a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).

7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

E. Fuses are specified in Section 262813 "Fuses."

F. Arc-Flash Limiting Feeder Circuit Breakers:

1. Feeder circuit breakers shall be without current-limiting fuses, listed as complying with UL 1066.
2. Short-circuit withstand current rating shall be 200 kA.
3. Equip the arc-flash limiting feeder circuit breakers with Arc-Flash Maintenance Setting switch for use as a temporary arc-flash incident energy-reduction device during maintenance activities on that feeder.

a. Provide a manual switch on the compartment door to switch the circuit-breaker short-time tripping characteristics to instantaneous with minimum pickup setting, to reduce the danger from potential arc-flash at downstream equipment.
b. Provide a lock feature for the switch so that it may be locked in either the off or on maintenance-mode position.
c. Provide a blue LED indicating light to indicate that the switch is in maintenance mode.
d. Provide dry relay contacts on each switch for annunciation of the switch position.

2.4 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:

1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

NOT FOR BIDDING PURPOSES

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
d. Megawatts: Plus or minus 1 percent.
e. Megavars: Plus or minus 1 percent.
f. Power Factor: Plus or minus 1 percent.
g. Frequency: Plus or minus 0.1 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

3. Provide ability for BAS connection.

C. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.

D. Instrument Switches: Rotary type with off position.

1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.

E. Ammeters: 2-1/2-inch minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.

F. Watt-Hour Meters and Wattmeters:

1. Comply with ANSI C12.1.
2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Integral demand indicator.
8. Contact devices to operate remote impulse-totalizing demand meter.
9. Ratchets to prevent reverse rotation.
10. Removable meter with drawout test plug.
11. Semiflush mounted case with matching cover.
12. Appropriate multiplier tag.

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G. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.
2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity, appropriate multiplier tag.
8. Capable of indicating and recording 15-minute integrated demand of totalized system.

2.5 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NECA 400 and NEMA PB 2.1.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
3. Protect from moisture, dust, dirt, and debris during storage and installation.
4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

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3.2 INSTALLATION

A. Install switchboards and accessories according to NECA 400 and NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, surge protection devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

3.3 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

C. Support and secure conductors within the switchboard according to NFPA 70.

D. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

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3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Acceptance Testing:

    a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
    b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. Perform the following infrared scan tests and inspections, and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:

        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

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6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Switchboard will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION 26 24 13

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SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Power panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Disconnecting and overcurrent protective devices.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. MCCB: Molded-case circuit breaker.

E. SPD: Surge protective device.

F. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Do not submit shop drawings until approved Short Circuit and Coordination Study has been submitted.

B. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

C. Shop Drawings: For each panelboard and related equipment.

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1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Include evidence of NRTL listing for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.
10. Key interlock scheme drawing and sequence of operations.
11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

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1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407 and NEMA PB 1.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: Two (2) years from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

E. Enclosures: Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Kitchen/Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2. Height: 84 inches maximum.

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3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
7. Finishes:

    a. Panels and Trim: galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    b. Back Boxes: Same finish as panels and trim.

F. Incoming Mains:

1. Location: Convertible between top and bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

G. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

    a. Plating shall run entire length of bus.
    b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.

H. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

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8. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.

I. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: Ten percent.

J. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.

2.3 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; by Schneider Electric. (Basis of Design)
2. Eaton.
3. ABB
4. SIEMENS Industry, Inc.; Energy Management Division.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker or lugs only as indicated on drawings.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

G. Branch Overcurrent Protective Devices: Fused switches.

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2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; by Schneider Electric. (Basis of Design)
2. Eaton.
3. ABB
4. SIEMENS Industry, Inc.; Energy Management Division.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only as indicated on drawings.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; by Schneider Electric. (Basis of Design)
2. Eaton.
3. ABB
4. SIEMENS Industry, Inc.; Energy Management Division.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:

a. RMS sensing.
b. Field-replaceable rating plug or electronic trip.
c. Digital display of settings, trip targets, and indicated metering displays.
d. Multi-button keypad to access programmable functions and monitored data.
e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.

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f. Integral test jack for connection to portable test set or laptop computer.
g. Field-Adjustable Settings:

1) Instantaneous trip.
2) Long- and short-time pickup levels.
3) Long and short time adjustments.
4) Ground-fault pickup level, time delay, and I squared T response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Subfeed Circuit Breakers: Vertically mounted.
9. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Breaker handle indicates tripped status.
c. UL listed for reverse connection without restrictive line or load ratings.
d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
i. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
j. Auxiliary Contacts: Two, SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
k. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
l. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
m. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
n. Multipole units enclosed in a single housing with a single handle.
o. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
p. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

NOT FOR BIDDING PURPOSES

1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."
2. Fused Switch Features and Accessories:

    a. Standard ampere ratings and number of poles.
    b. Mechanical cover interlock with a manual interlock override, to prevent the opening of the cover when the switch is in the on position. The interlock shall prevent the switch from being turned on with the cover open. The operating handle shall have lock-off means with provisions for three padlocks.
    c. Auxiliary Contacts: Two normally open and normally closed contact(s) that operate with switch handle operation.

2.6 ARC-FLASH LIMITING FEEDER CIRCUIT BREAKERS

A. Feeder circuit breakers shall be without current-limiting fuses, listed as complying with UL 1066.

B. Short-circuit withstand current rating shall be 200kA.

C. Equip the arc-flash limiting feeder circuit breakers with Arc-Flash Maintenance Setting switch for use as a temporary arc-flash incident energy-reduction device during maintenance activities on that feeder.

1. Provide a manual switch on the compartment door to switch the circuit-breaker short-time tripping characteristics to instantaneous with minimum pickup setting to reduce the danger from potential arc-flash at downstream equipment.
2. Provide a lock feature for the switch so that it may be locked in either the off or on maintenance-mode position.
3. Provide a blue LED indicating light to indicate that the switch is in maintenance mode.
4. Provide dry relay contacts on each switch for annunciation of the switch position.

2.7 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

NOT FOR BIDDING PURPOSES

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407 and NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407 and NEMA PB 1.1.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

E. Mount top of trim not higher than 6’-6” above finished floor unless otherwise indicated. No operating handles, pushbuttons, switches or other operating devices shall be mounted higher than 6’-0” above finished floor to the highest point of the operating device. Adjust mounting heights as required to suit field conditions.

F. Mount panelboard cabinet plumb and rigid without distortion of box.

G. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

H. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

NOT FOR BIDDING PURPOSES

2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

I. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes and connections to separate ground bars.

J. Install filler plates in unused spaces.

K. For recessed panelboards, stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.

L. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

M. Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.

NOT FOR BIDDING PURPOSES

2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Do not perform optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

NOT FOR BIDDING PURPOSES

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 24 16

NOT FOR BIDDING PURPOSES

SECTION 26 27 13

ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electricity meters.
2. Work to accommodate utility company revenue meters, and Owner's electricity meters used to manage electrical power system.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 DEFINITIONS

A. KY or KYZ Pulse: Term used by metering industry to describe method of measuring consumption of electricity (kWh) that is based on relay opening and closing in response to rotation of disk in meter. Electronic meters generate pulses electronically.

1.3 COORDINATION

A. Electrical Service Connections:

1. Coordinate with utility companies and utility-furnished components.

a. Comply with requirements of utility providing electrical power services.
b. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

1.4 ACTION SUBMITTALS

A. Product Data:

1. For each type of meter.
2. For metering infrastructure components.
3. For metering software.

B. Shop Drawings: For electricity-metering equipment.

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1. Include elevation views of front panels of control and indicating devices and control stations.
2. Include diagrams for power, signal, and control wiring.
3. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include series-combination rating data for modular meter centers with main disconnect device.
5. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.
6. Submit evidence that meters are compatible with connected monitoring and control devices and systems specified in Section 260913 "Electrical Power Monitoring and Control."

    a. Show interconnecting signal and control wiring, and interface devices to show compatibility of meters.
    b. For reporting interfaces and adapters, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the protocol.

C. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation and testing instructions issued to Installer by manufacturer for the following:

1. Installation of metering equipment.

B. Sample warranties.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Contracts:

1. Software and firmware service agreement.

B. Warranty documentation.

NOT FOR BIDDING PURPOSES

1.7 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed metering equipment performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

B. Comply with UL 916.

2.2 UTILITY METERING INFRASTRUCTURE

A. Install metering accessories furnished by utility company, complying with its requirements.

B. Utility-Furnished Meters: Connect data transmission facility of metering equipment installed by Utility.

1. Data Transmission: Transmit pulse data over control-circuit conductors, classified as Class 1 per NFPA 70, Article 725. Comply with Section 260523 "Control-Voltage Electrical Power Cables."

C. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.

D. Meter Sockets:

1. Comply with requirements of electrical-power utility company.
2. Steady-state and short-circuit current ratings must meet indicated circuit ratings.

E. Modular Meter Center: Factory-coordinated assembly of main service disconnect device, wireways, meter socket modules, and feeder circuit breakers arranged in adjacent vertical sections complete with interconnecting buses.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Square D; Schneider Electric USA. (Basis of Design)
b. ABB, Electrification Business.
c. Eaton.
d. Leviton Manufacturing Co., Inc.
e. Siemens Industry, Inc., Energy Management Division.

2. Comply with requirements of utility company for meter center.

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a. Comply with UL 67.

3. Housing: UL 50E, Type 3R enclosure.
4. Meter Socket Rating: Coordinated with connected feeder circuit rating.
5. Minimum Short-Circuit Rating: 65 000 A symmetrical at rated voltage.
6. Steady-state and short-circuit current ratings must have ratings that match connected circuit ratings.
7. Main Disconnect Device:

   a. Circuit breaker, series-combination rated for use with downstream feeder and branch circuit breakers and having adjustable magnetic trip setting for circuit-breaker frame sizes of 250 A and larger. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers." Circuit breakers must be operable from outside enclosure to disconnect unit. Configure cover so it can be opened only when disconnect switch is open.
   b. Fusible switch, UL 98 Type GD, series-combination rated by fuse manufacturer to protect downstream feeder and branch circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers." Switch must be operable from outside enclosure to disconnect unit. Configure cover so that it can be opened only when disconnect switch is open.

8. Feeder Circuit Breakers: Series-combination-rated molded-case units, rated to protect downstream circuit breakers and to house load centers and panelboards that have 10 000 A interrupting capacity.

   a. Identification: Complying with requirements in Section 260553 "Identification for Electrical Systems."
   b. Physical Protection: Tamper resistant, with hasp for padlock.

9. Surge Protection:

   a. Factory-installed in main disconnect, integrally mounted, UL 1449 Type 1. Comply with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

F. Arc-Flash Warning Labels:

1. Comply with requirements for "Arc-Flash Warning Labels" in Section 260573.19 "Arc-Flash Studies." Apply 3-1/2-by-5 inch thermal transfer label of high-adhesion polyester for each work location included in the analysis.

2.3 ELECTRICITY METERS

A. System Description: Able to meter designated activity loads, with or without external alarm, control, and communication capabilities, or other optional features.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; Schneider Electric USA. (Basis of Design)

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2. ABB, Electrification Business.
3. Davidge Controls.
4. E-Mon.
5. Eaton.
6. GE Power; General Electric Company.
7. Leviton Manufacturing Co., Inc.
8. National Meter Industries.
9. Sensus Metering Systems.
10. Siemens Industry, Inc., Energy Management Division.

C. General Requirements for Meters:

1. Comply with NEMA ANSI C12.1 and NEMA ANSI C12.20, 0.1 accuracy class.
2. Ambient Temperature: Minus 22 deg F to plus 158 deg F.
3. Humidity: Zero to 95 percent, noncondensing.
4. Capacities and Characteristics:

    a. Circuit: 120/240 V(ac), 100 A.
    b. Measure: kWh, onboard LED display.
    c. Remote-Reading Options: None.

5. Certify that meters comply with NEMA ANSI C12.20 requirements by laboratory accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology (NIST). Laboratory must use test equipment that is certified annually and is traceable to NIST standards.
6. Enclosure: Supplied by meter manufacturer, UL 50E, Type 3R minimum, with provisions for locking or sealing.
7. Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems."
8. Onboard Nonvolatile Data Storage: kWh, until reset.
9. Sensors: Current-sensing type, supplied by electronic meter manufacturer, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.

    a. Type: solid core, complying with recommendation of meter manufacturer.

D. kWh Meter: Electronic three-phase meters, measuring electricity use.

1. Voltage and Phase Configuration: Meter must be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display:
    a. Digital electromechanical counter, indicating accumulative kWh.

E. kWhd Meter: Electronic three-phase meters, measuring electricity use and demand. Demand must be integrated over 15-minute interval.

1. Voltage and Phase Configuration: Meter must be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display: LCD with characters not less than 0.25 inch high, indicating the following:

    a. Accumulative kWh.

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b. Current time and date.
c. Current demand.
d. Historic peak demand.
e. Time and date of historic peak demand.

3. Retain accumulated kWh and historic peak demand in nonvolatile memory, until reset.

F. Data Transmission Cable: Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Install modular meter center according to switchboard installation requirements in NECA 400.
2. Install arc-flash labels as required by NFPA 70.

C. Special Techniques:

1. Install meter furnished by utility company. Install raceways and equipment according to utility company's published instructions. Provide empty conduits for metering leads and extend grounding connections as required by utility company.
2. Wiring Methods:

a. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533.13 "Conduits for Electrical Systems."
b. Minimum conduit size is metric designator 16 (trade size 1/2).

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Series Combination Warning Label: Self-adhesive labels, with text as required by NFPA 70.
2. Equipment Identification Labels: Self-adhesive labels with clear protective overlay. For residential meters, provide additional card holder suitable for printed, weather-resistant card with occupant's name.

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

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B. Field tests and inspections must be witnessed by authorities having jurisdiction.

C. Tests and Inspections:

1. Equipment and Software Setup:

a. Set meter date and time clock.
b. Test, calibrate, and connect pulse metering system.
c. Set and verify billing demand interval for demand meters.
d. Report settings and calibration results.
e. Set up reporting and billing software, insert billing location names and initial constant values and variable needed for billing computations.

2. Connect load of known power rating, 1.5 kW minimum, to circuit supplied by metered feeder.
3. Turn off circuits supplied by metered feeder and secure them in off condition.
4. Run test load continuously for eight hours minimum, or longer, to obtain measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
5. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.
6. Generate test report and billing for each tenant or activity from meter reading tests.

D. Nonconforming Work:

1. Electricity metering will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

E. Collect, assemble, and submit test and inspection reports.

F. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

3.4 PROTECTION

A. After installation, protect metering equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 13

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SECTION 26 27 16

ELECTRICAL CABINETS AND ENCLOSURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cabinets and cutout boxes.
2. Termination boxes.
3. Miscellaneous enclosures.

B. Products Installed, but Not Furnished, under This Section:

1. See Section 260553 "Identification for Electrical Systems" for equipment labels.

C. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 DEFINITIONS

A. RBB: Rack bonding busbar, located in equipment cabinets and racks.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Cabinets and cutout boxes.
2. Termination boxes.
3. Miscellaneous enclosures.

B. Shop Drawings:

1. Shop drawings for custom enclosures and cabinets.

PART 2 - PRODUCTS

2.1 CABINETS AND CUTOUT BOXES

A. Performance Criteria:

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1. Regulatory Requirements:

    a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Listing Criteria:

    a. UL CCN CYIV.
    b. Non-Environmental Characteristics: UL 50.
    c. Environmental Characteristics: UL 50E.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL CYIV - Indoor Sheet Metal Cabinets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Cooper B-line; brand of Eaton, Electrical Sector.
    c. Crouse-Hinds; brand of Eaton, Electrical Sector.
    d. Hoffman; brand of nVent Electrical plc.
    e. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    f. Siemens Industry, Inc., Building Technologies Division.
    g. Square D; Schneider Electric USA.

2. General Characteristics: Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
3. Options:

    a. Degree of Protection: Type 1.

D. UL CYIV - Indoor Sheet Metal Cutout Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Cooper B-line; brand of Eaton, Electrical Sector.
    c. Crouse-Hinds; brand of Eaton, Electrical Sector.
    d. Hoffman; brand of nVent Electrical plc.
    e. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    f. Siemens Industry, Inc., Building Technologies Division.
    g. Square D; Schneider Electric USA.

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2. General Characteristics: Enclosure that has swinging doors or covers secured directly to and telescoping with walls of enclosure.
3. Options:

a. Degree of Protection: Type 1.

E. UL CYIV - Outdoor Sheet Metal Cabinets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Hoffman; brand of nVent Electrical plc.
e. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. Siemens Industry, Inc., Building Technologies Division.
g. Square D; Schneider Electric USA.

2. General Characteristics: Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
3. Options:

a. Degree of Protection: Type 3R.

F. UL CYIV - Outdoor Sheet Metal Cutout Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. Hoffman; brand of nVent Electrical plc.
e. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
f. Siemens Industry, Inc., Building Technologies Division.
g. Square D; Schneider Electric USA.

2. General Characteristics: Enclosure that has swinging doors or covers secured directly to and telescoping with walls of enclosure.
3. Options:

a. Degree of Protection: Type 3R.

2.2 TERMINATION BOXES

A. Description: Enclosure for termination base consisting of lengths of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors or both.

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B. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Listing Criteria:

a. UL CCN XCKT; including UL 1773.
b. Non-Environmental Characteristics: UL 50.
c. Environmental Characteristics: UL 50E.

C. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

D. UL XCKT - Termination Boxes and Termination Bases for Installation on Line Side of Service Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. Hoffman; brand of nVent Electrical plc.
d. Square D; Schneider Electric USA.

2. Additional Characteristics: Listed and labeled for installation on line side of service equipment.
3. Options:

a. Indoor Degree of Protection: Type 1.
b. Outdoor Degree of Protection: Type 3R.

E. UL XCKT - Termination Boxes and Termination Bases for Installation on Load Side of Service Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Cooper B-line; brand of Eaton, Electrical Sector.
c. Hoffman; brand of nVent Electrical plc.
d. Square D; Schneider Electric USA.

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2. Additional Characteristics: Listed and labeled for installation on load side of service equipment.
3. Options:

    a. Indoor Degree of Protection: Type 1.
    b. Outdoor Degree of Protection: Type 3R.

2.3 MISCELLANEOUS ENCLOSURES

A. Performance Criteria:

1. Regulatory Requirements:

    a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Listing Criteria:

    a. UL CCN XCKT; including UL 1773.
    b. Non-Environmental Characteristics: UL 50.
    c. Environmental Characteristics: UL 50E.

B. Source Quality Control:

1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

C. UL XCKT - Indoor Sheet Metal Miscellaneous Enclosures:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Cooper B-line; brand of Eaton, Electrical Sector.
    c. Hoffman; brand of nVent Electrical plc.
    d. Square D; Schneider Electric USA.

2. Options:

    a. Degree of Protection: Type 1.

D. UL XCKT - Outdoor Sheet Metal Miscellaneous Enclosures:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.

NOT FOR BIDDING PURPOSES

b. Cooper B-line; brand of Eaton, Electrical Sector.
c. Hoffman; brand of nVent Electrical plc.
d. Square D; Schneider Electric USA.

2. Options:

a. Degree of Protection: Type 3R.

PART 3 - EXECUTION

3.1 PREPARATION

A. Shop Drawings: Prepare and submit the following:

1. Shop Drawings for Custom Enclosures and Cabinets: Include plans, elevations, sections, and attachment details.
2. Shop Drawings for Racks or Frames:

a. Include plans, elevations, sections, details, and attachments to other work.
b. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
c. Include workspace requirements and access for cable connections.
d. Grounding: Indicate location of RBB and its mounting detail showing standoff insulators and wall-mounting brackets.

3.2 SELECTION OF ELECTRICAL CABINETS AND ENCLOSURES

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of electrical cabinets and enclosures. Consult Architect for resolution of conflicting requirements.

B. Degree of Protection:

1. Outdoors:

a. Type 3R unless otherwise indicated.
b. Locations Exposed to Hosedown: Type 4.
c. Locations Subject to Potential Flooding: Type 6P.
d. Locations Aboveground Where Mechanism Must Operate When Ice Covered: Type 3S.

2. Indoors:

a. Type 1 unless otherwise indicated.

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b. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
c. Flush Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12K.
d. Locations Exposed to Hosedown: Type 4.
e. Locations Exposed to Brief Submersion: Type 6P.
f. Locations Exposed to Prolonged Submersion: Type 6P.
g. Locations Exposed to Spraying Oil or Coolants: Type 13.

3.3 INSTALLATION OF ELECTRICAL CABINETS AND ENCLOSURES

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:

1. Cabinets and Cutout Boxes: Article 312 of NFPA 70.
2. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Mount cabinets and enclosures at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to top of box unless otherwise indicated.
2. Do not install cabinets, enclosures, or fittings in contact with concrete or earth.
3. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
4. Identification: Provide labels for cabinets, enclosures, racks and associated electrical equipment.

a. Identify field-installed conductors, interconnecting wiring, and components.
b. Provide warning signs.
c. Label each cabinet, enclosure, and rack with engraved metal or laminated-plastic nameplate.

D. Interfaces with Other Work:

1. Coordinate with Section 078413 "Penetration Firestopping" for installation of sealants.
2. Grounding and Bonding:

a. Cabinets, Enclosures, and Racks for Electrical Systems: Coordinate with Section 260526 "Grounding and Bonding for Electrical Systems" for grounding of RBBs.
b. Cabinets, Enclosures, and Racks for Communications Systems and Electronic Safety and Security Systems: Coordinate with Section 260526 "Grounding and Bonding for Electrical Systems" for grounding of RBBs.

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3. Coordinate with Section 260573.13 "Short-Circuit Studies" for determining available fault current on input feeder.
4. Coordinate with Section 260573.19 "Arc-Flash Hazard Analysis" for determining arc-flash hazard on input feeder.

3.4 CLEANING

A. Remove construction dust and debris from cabinets, enclosures, and racks.

3.5 PROTECTION

A. Protect coatings and finishes of cabinets, enclosures, and racks from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 27 16

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SECTION 26 27 19

MULTI-OUTLET ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Floor-mounted, recessed metal raceway multi-outlet assemblies.
2. Floor-mounted, enclosure multi-outlet assemblies.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260533.13 "Conduits for Electrical Systems" for raceways.
3. Section 260533.16 "Boxes and Covers for Electrical Systems" for floor boxes and covers.
4. Section 262726 "Wiring Devices" for receptacles and switches.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Floor-mounted, recessed metal raceway multi-outlet assemblies.
2. Floor-mounted, enclosure multi-outlet assemblies.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED, RECESSED METAL RACEWAY MULTI-OUTLET ASSEMBLIES

A. Description: Two-piece flush-mounted, in-floor, metal raceway, with factory-wired multi-outlet harness, for installation flush in floor or under floor finish.

B. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

C. General Characteristics:

1. Reference Standards: UL 5 for exposed power raceway and fittings, UL 5C for exposed communications raceway and fittings, and UL 2024 for communications cable routing.
2. Provide separate paths for management of telecommunications and power cables.

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D. Source Limitations: Obtain products from single manufacturer designed for use as complete, matching assembly of raceways and receptacles.

E. Floor-Mounted, Recessed Metal Raceway Power Multi-Outlet Assembly:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   b. Wiremold; Legrand North America, LLC.

2. Options:

   a. Load-Bearing Capacity: 1000 lb.
   b. Material: Aluminum, with manufacturer's standard finish.
   c. Color: As selected by Architect.
   d. Power Outlets: in accordance with Section 262726 "Wiring Devices" in surface-mounted enclosure capable of mounting anywhere along length of recessed raceway.
   e. Wiring: Single circuit in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Floor-Mounted, Recessed Metal Raceway Power and Communications Multi-Outlet Assembly:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   b. Wiremold; Legrand North America, LLC.

2. Options:

   a. Load-Bearing Capacity: 1000 lb.
   b. Material: Aluminum, with manufacturer's standard finish.
   c. Color: As selected by Architect.
   d. Power Outlets: in accordance with Section 262726 "Wiring Devices" in surface-mounted enclosure capable of mounting anywhere along length of recessed raceway.
   e. Power Wiring: Single circuit in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
   f. Voice and Data Communication Outlets: complying with requirements in Section 271500 "Communications Horizontal Cabling."
   g. Cables in accordance with Section 271513 "Communications Copper Horizontal Cabling" for each outlet.

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2.2 FLOOR-MOUNTED ENCLOSURE MULTI-OUTLET ASSEMBLIES

A. Description: Floor-mounted box with cover enclosing multiple power and communications outlets in a single assembly.

B. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

C. General Characteristics:

1. Reference Standards: UL 514A for metallic boxes; UL 514C for nonmetallic boxes, including scrub-water exclusion requirements; and UL 514D for cover plates.
2. Provide separate paths for management of telecommunications and power cables in accordance with NFPA 76.
3. Compartments: Barrier separates power from voice and data communication cabling.

D. Source Limitations: Obtain products from single manufacturer designed for use as complete, matching assembly of raceways and receptacles.

E. Floor-Mounted Enclosure Multi-Outlet Assembly:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Wiremold; Legrand North America, LLC.

2. Options:

a. Floor Box and Cover:

1) Provide floor boxes classified for use in 2-hour-rated concrete floors. Boxes for floors in contact with earth must be protected with an epoxy paint.
2) Floor boxes for concrete floors must provide a minimum of 4 inch of adjustment prior to concrete pour and a minimum of 1/2 inch after concrete is set.
3) Provide quantity of gangs as indicated on drawings.
4) Provide brass or aluminum flanges approved for use on carpet, tile, or wood floor applications. Flanges and cover plates must have a buffed appearance and a protective finish. Covers must match appearance of floor flanges and provide access to included devices.
5) Covers must lay flat on floor surface when open. Provide for cable egress when cover is closed. Provide ADA-compliant covers.
6) Provide flanges, mounting brackets, keystones, and accessories for mounting devices and connections indicated on Drawings.

b. Outlets:

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1) Power Outlets: in accordance with Section 262726 "Wiring Devices."
2) Wiring: Single circuit in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
3) Voice and Data Communication Outlets: As indicated on drawings.
4) Cables in accordance with Section 271513 "Communications Copper Horizontal Cabling" for each outlet.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1 for device mounting heights, except where requirements on Drawings or in this Section are stricter.

B. Comply with NECA 101 for installation requirements for steel raceways, except where requirements on Drawings or in this Section are stricter.

C. Comply with NECA 102 for installation requirements for aluminum raceways, except where requirements on Drawings or in this Section are stricter.

D. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies.

E. Provide terminations, adapters, boxes, and other fittings required for installation.

F. Install surface raceway with a minimum 2 inch radius control at bend points.

G. Secure metallic surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inch and with no fewer than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's instructions. Tape and glue are unacceptable support methods.

H. Do not install aluminum raceways or fittings in contact with concrete.

I. Secure nonmetallic surface raceway with screws or other anchor-type devices in each wiring channel at intervals not exceeding 18 inch and with no fewer than two supports per straight raceway section in each wiring channel. Support nonmetallic surface raceway in accordance with manufacturer's instructions. Tape and glue are unacceptable support methods.

J. Do not install PVC raceways where ambient temperature exceeds 122 deg F. Conductors with insulation rated higher than 75 deg C installed in PVC raceways may not be operated at a temperature greater than 75 deg C.

K. Comply with Section 260526 "Grounding and Bonding for Electrical Systems."

L. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and support.

M. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.23 "Surface Raceways for Electrical Systems" for installation of raceways.

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N. Comply with requirements in Section 260533.16 "Boxes and Covers for Electrical Systems" for additional requirements for floor boxes.

O. Coordination with Other Work:

1. Adjust locations of multi-outlet assemblies to suit arrangement of partitions and furnishings. Locate outlets to avoid blocking by supports, furnishings, and other architectural fixtures.
2. Provide outlets with special requirements, such as GFCI, or special environmental requirements, where required by Drawings or to meet codes.
3. Adjust locations of poke-through assembly penetrations to coordinate with locations of structural members, concealed piping, and concealed conduit. Obtain written approval from Architect prior to drilling penetrations in floors other than where dimensioned on architectural Drawings. Comply with requirements in Section 078413 "Penetration Firestopping."

3.2 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

END OF SECTION 26 27 19

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SECTION 26 27 26.11

GENERAL-USE SWITCHES, DIMMER SWITCHES, AND FAN-SPEED CONTROLLER SWITCHES

NOT FOR BIDDING PURPOSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-use switches.
2. General-use dimmer switches.
3. General-use fan-speed controller switches.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260923 "Lighting Control Devices" for occupancy sensors, timers, control-voltage switches, and control-voltage dimmers.
3. Section 260936 "Modular Dimming Controls" for multiscene and multipreset dimming controls.

1.2 DEFINITIONS

A. UL 1472 Type I Dimmer: Dimmer in which air-gap switch is used to energize preset lighting levels.

B. UL 1472 Type II Dimmer: Dimmer with air-gap switch that opens and closes load circuit at minimum output voltage setting only.

C. UL 1472 Type IIa Dimmer: Dimmer with air-gap switch that opens and closes load circuit at maximum output voltage setting only.

D. UL 1472 Type III Dimmer: Dimmer incorporating solid-state components providing preestablished rectified output settings.

E. UL 1472 Type IV Dimmer: Dimmer not covered by UL 1472 Types I through III.

1.3 ACTION SUBMITTALS

A. Product Data:

1. General-use switches.

2. General-use dimmer switches.
3. General-use fan-speed controller switches.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' Instructions: Record copy of official installation and testing instructions issued to Installer by manufacturer for the following:

1. Dimmers.
2. Fan-speed controllers.

PART 2 - PRODUCTS

2.1 GENERAL-USE SWITCHES

A. Description: Snap switches intended for mounting in device boxes.

B. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. General Characteristics:

a. Reference Standards: UL CCN WMUZ and UL 20.

C. Toggle Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour; Legrand North America, LLC.

2. Options:

a. Device Color: As selected by Architect.
b. Configuration:

1) Extra-heavy-duty, 120-277 V, 20 A, single pole, three way, or four way.

D. Toggle Switch with Pilot Light:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour; Legrand North America, LLC.

2. Options:

    a. Device Color: As selected by Architect.
    b. Configuration:

        1) Illuminated when load off, 120-277 V, 20 A, single pole or three way.

E. Maintained-Contact, Center-Off, Toggle Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour; Legrand North America, LLC.

2. Options:

    a. Device Color: As selected by Architect.
    b. Configuration:

        1) Single pole, double throw, 120-277 V, 20 A.

F. Momentary-Contact, Center-Off, Toggle Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour; Legrand North America, LLC.

2. Options:

    a. Device Color: As selected by Architect.
    b. Configuration: Single pole, double throw, 120-277 V, 20 A.

G. Rocker Switch:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour; Legrand North America, LLC.

2. Options:

    a. Device Color: As selected by Architect.
    b. Configuration:

        1) 120-277 V, 20 A, single pole, three way, or four way.

H. Rocker Switch with Pilot Light:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour; Legrand North America, LLC.

2. Options:

    a. Device Color: As selected by Architect.
    b. Configuration:

        1) Illuminated when load on, 120-277 V, 20 A, single pole or three way.

2.2 GENERAL-USE DIMMER SWITCHES

A. Description: Line-voltage dimmers intended for mounting in flush device boxes or on outlet box covers (wall box).

B. Performance Criteria:

1. Regulatory Requirements:

    a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. General Characteristics:

    a. Reference Standards: UL CCN EOYX and UL 1472.

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C. Type I Dimmer Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. GE Lighting; a Savant Company.
c. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. Leviton Manufacturing Co., Inc.
e. Lutron Electronics Co., Inc.
f. Pass & Seymour; Legrand North America, LLC.

2. Additional Characteristics: UL 1472 Type I dimmer.
3. Options:

a. Device Color: As selected by Architect.
b. Switch Style: Toggle.
c. Dimming Control Style: Slide.

D. Type II Dimmer Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. GE Lighting; a Savant Company.
c. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. Leviton Manufacturing Co., Inc.
e. Lutron Electronics Co., Inc.
f. Pass & Seymour; Legrand North America, LLC.

2. Additional Characteristics:

a. UL 1472 Type II dimmer.
b. Switch Style: Air-gap switch at dimmer control end of travel at minimum output voltage.

3. Options:

a. Device Color: As selected by Architect.
b. Dimming Control Style: Slide.

E. Type IIa Dimmer Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. GE Lighting; a Savant Company.

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c. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. Leviton Manufacturing Co., Inc.
e. Lutron Electronics Co., Inc.
f. Pass & Seymour; Legrand North America, LLC.

2. Additional Characteristics:

a. UL 1472 Type IIa dimmer.
b. Switch Style: Air-gap switch at dimmer control end of travel at maximum output voltage.

3. Options:

a. Device Color: As selected by Architect.
b. Dimming Control Style: Slide.

F. Type III Dimmer Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. GE Lighting; a Savant Company.
c. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. Leviton Manufacturing Co., Inc.
e. Lutron Electronics Co., Inc.
f. Pass & Seymour; Legrand North America, LLC.

2. Additional Characteristics: UL 1472 Type III dimmer.
3. Options:

a. Device Color: As selected by Architect.
b. Switch Style: Push-button.
c. Dimming Control Style: Push-button.
d. Network connection to provide programmable presets, scenes, and time-clock.

2.3 GENERAL-USE FAN-SPEED CONTROLLER SWITCHES

A. Description: Semiconductor, capacitive-type, and inductive-type fan-speed controllers for regulating speed of fan motor, including starting and stopping of fan motor, intended for mounting in flush device boxes or on outlet box covers (wall box).

B. Performance Criteria:

1. Regulatory Requirements:

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a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. General Characteristics:

a. Reference Standards: UL CCN GQHG and UL 1917.

C. Air-Gap Fan-Speed Controller Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour; Legrand North America, LLC.

2. Options:

a. Device Color: As selected by Architect.

D. Solid-State Fan-Speed Controller Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. Options:

a. Device Color: As selected by Architect.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Consult Architect for resolution of conflicting requirements.

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C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

3.2 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Engineer.

B. Tests and Inspections:

1. Perform tests and inspections in accordance with manufacturers' instructions.

C. Nonconforming Work:

1. Unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Assemble and submit test and inspection reports.

3.3 SYSTEM STARTUP

A. Perform startup service.

1. Complete installation and startup checks for momentary switches, dimmer switches, and fan-speed controller switches in accordance with manufacturer's instructions.

3.4 PROTECTION

A. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.

B. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26.11

NOT FOR BIDDING PURPOSES

SECTION 26 27 26.33

GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Duplex straight-blade receptacles.
2. Duplex straight-blade receptacles with integral switching means.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 262726.35 "Hospital-Grade Straight-Blade Receptacles" for hospital-grade receptacles.
3. Section 262726.37 "Receptacles with Ground-Fault Protective Devices" for GFCI receptacles.
4. Section 262726.39 "Locking Receptacles" for twist-locking receptacles.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Duplex straight-blade receptacles with integral switching means.

B. Shop Drawings:

1. Wiring diagrams for duplex straight-blade receptacles with integral switching means.

C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' Instructions: Record copy of official installation instructions issued to Installer by manufacturer for the following:

1. Duplex straight-blade receptacles with integral switching means.

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PART 2 - PRODUCTS

2.1 DUPLEX STRAIGHT-BLADE RECEPTACLES WITH INTEGRAL SWITCHING MEANS

A. Description: Controlled receptacles with integral switching means, intended to be installed on a 20 A maximum branch circuit and for use in dry locations, in accordance with NFPA 70.

B. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. General Characteristics:

a. Reference Standards: UL CCN RTXI and UL Subject 498B.

C. Wired Full-Controlled Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Pass & Seymour; Legrand North America, LLC.

2. Options:

a. Device Color: As selected by Architect.
b. Configuration: NEMA 5-20R.

D. Wired Half-Controlled Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Pass & Seymour; Legrand North America, LLC.

2. Options:

a. Device Color: As selected by Architect.
b. Configuration: NEMA 5-20R.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2 INSTALLATION

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
4. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

    a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
    b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

NOT FOR BIDDING PURPOSES

B. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Assemble and submit test and inspection reports.

3.4 PROTECTION

A. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.

B. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26.33

NOT FOR BIDDING PURPOSES

SECTION 26 27 26.35

HOSPITAL-GRADE STRAIGHT-BLADE RECEPTACLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hospital-grade straight-blade receptacles.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" for duplex receptacles that are not hospital grade.
3. Section 262726.37 "Receptacles with Ground-Fault Protective Devices" for GFCI receptacles.
4. Section 262726.39 "Locking Receptacles" for twist-locking receptacles.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Hospital-grade straight-blade receptacles.

B. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' Instructions: Record copy of official installation instructions issued to Installer by manufacturer for the following:

1. Hospital-grade straight-blade receptacles.

PART 2 - PRODUCTS

2.1 HOSPITAL-GRADE STRAIGHT-BLADE RECEPTACLES

A. Description: Hospital-grade duplex receptacles for use in wiring systems recognized by NFPA 70.

NOT FOR BIDDING PURPOSES

B. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. General Characteristics:

a. Reference Standards:

1) UL CCN RTRT and UL 498.
2) Surge Protective Devices: UL 1449, Type 3.

C. Hospital-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour; Legrand North America, LLC.

2. Options:

a. Device Color: As selected by Architect.
b. Configuration:

1) Extra-heavy-duty, NEMA 5-20R.

D. Hospital-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with USB Outlet to Power Class 2 Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Pass & Seymour; Legrand North America, LLC.

2. Options:

a. Device Color: As selected by Architect.
b. Configuration:

1) Heavy-duty, NEMA 5-20R; one USB-A port; one USB-C port.

NOT FOR BIDDING PURPOSES

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2 INSTALLATION

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.

    a. Hospital-Grade Receptacle Orientation: Orient receptacle with ground pin or neutral pin at top.

4. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

    a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
    b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity: impedance must be not greater than 2 ohms.

NOT FOR BIDDING PURPOSES

6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

B. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Assemble and submit test and inspection reports.

3.4 PROTECTION

A. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.

B. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26.35

NOT FOR BIDDING PURPOSES

SECTION 26 27 26.37

RECEPTACLES WITH GROUND-FAULT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Receptacles with GFCI devices.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" for duplex receptacles that are not hospital grade.
3. Section 262726.35 "Hospital-Grade Straight-Blade Receptacles" for hospital-grade receptacles.
4. Section 262726.39 "Locking Receptacles" for twist-locking receptacles.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Receptacles with GFCI devices.

B. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' Instructions: Record copy of official installation [and testing] instructions issued to Installer by manufacturer for the following:

1. Receptacles with GFCI devices.

PART 2 - PRODUCTS

2.1 RECEPTACLES WITH GFCI DEVICES

A. Description: Receptacles containing GFCI device for use in accordance with NFPA 70.

B. Performance Criteria:

NOT FOR BIDDING PURPOSES

1. Regulatory Requirements:

    a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. General Characteristics:

    a. Reference Standards: UL CCN KCXS, UL 498, and UL 943.

C. Hospital-Grade Duplex Straight-Blade Receptacle with GFCI Device:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour; Legrand North America, LLC.

2. Options:

    a. Device Color: As selected by Architect.
    b. Configuration: Heavy-duty, NEMA 5-20R.

D. Hospital-Grade, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour; Legrand North America, LLC.

2. Options:

    a. Device Color: As selected by Architect.
    b. Configuration: Heavy-duty, NEMA 5-20R.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

NOT FOR BIDDING PURPOSES

3.2 SELECTION OF GFCI RECEPTACLES

A. Healthcare Facilities: Unless protection of downstream branch-circuit wiring, cord sets, and power-supply cords is required by NFPA 70 or NFPA 99, provide non-feed-through GFCI receptacles.

3.3 INSTALLATION

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.

    a. Hospital-Grade Receptacle Orientation: Orient receptacle with ground pin or neutral pin at top.

4. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

    a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
    b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity: impedance must be not greater than 2 ohms.
6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).

NOT FOR BIDDING PURPOSES

7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

B. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Assemble and submit test and inspection reports.

3.5 PROTECTION

A. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.

B. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26.37

NOT FOR BIDDING PURPOSES

SECTION 26 27 26.39

LOCKING RECEPTACLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Locking receptacles.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" for duplex receptacles that are not hospital grade.
3. Section 262726.35 "Hospital-Grade Straight-Blade Receptacles" for hospital-grade receptacles.
4. Section 262726.37 "Receptacles with Ground-Fault Protective Devices" for GFCI receptacles.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Locking receptacles.

B. Field Quality-Control Submittals:

1. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' Instructions: Record copy of official installation instructions issued to Installer by manufacturer for the following:

1. Locking receptacles.

NOT FOR BIDDING PURPOSES

PART 2 - PRODUCTS

2.1 LOCKING RECEPTACLES

A. Description: Receptacles that require two motions, insertion and rotation, to fully mate attachment plugs.

B. Performance Criteria:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. General Characteristics:

a. Reference Standards: UL CCN RTRT and UL 498.

C. NEMA, 125 V, Locking Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour; Legrand North America, LLC.

2. Options:

a. Device Color: Black with yellow voltage indication on face.
b. Configuration: 2 pole, 3 wire, grounding, as indicated on drawings.

D. NEMA, 125/250 V, Locking Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour; Legrand North America, LLC.

2. Options:

a. Device Color: Black with orange voltage indication on face.
b. Configuration:

NOT FOR BIDDING PURPOSES

1) 3 pole, 3 wire, non-grounding, as indicated on drawings.
2) 3 pole, 4 wire, grounding, as indicated on drawings.

E. NEMA, 250 V, Locking Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour; Legrand North America, LLC.

2. Options:

a. Device Color: Black with blue voltage indication on face.
b. Configuration:

1) 2 pole, 3 wire, grounding, as indicated on drawings.
2) 3 pole, 4 wire, grounding, as indicated on drawings.
3) 4 pole, 4 wire, non-grounding, as indicated on drawings.
4) 4 pole, 5 wire, grounding, as indicated on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2 INSTALLATION

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
4. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

NOT FOR BIDDING PURPOSES

a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity: impedance must be not greater than 2 ohms.
6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

B. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Assemble and submit test and inspection reports.

3.4 PROTECTION

A. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.

B. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 27 26.39

NOT FOR BIDDING PURPOSES

SECTION 26 28 13

FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:

a. Control circuits.
b. Enclosed controllers.
c. Enclosed switches.

2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software and in PDF format.
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

NOT FOR BIDDING PURPOSES

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017700 "Closeout Procedures" and Section 017823 "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software and in PDF format.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bussmann; Eaton, Electrical Sector. (Basis of Design)
2. Littelfuse, Inc.
3. Mersen USA.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.

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2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.
3. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 10 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch-high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

NOT FOR BIDDING PURPOSES

1. Motor Branch Circuits: Class RK1, time delay.
2. Large Motor Branch (601-4000 A): Class L, time delay.
3. Other Branch Circuits: Class J, time delay.
4. Control Transformer Circuits: Class CC, time delay, control transformer duty.
5. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Owner.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 26 28 13

NOT FOR BIDDING PURPOSES

SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Elevator Main Line (Motor) Disconnect Switch
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Molded-case switches.
7. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

NOT FOR BIDDING PURPOSES

6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF and electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF and electronic format.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

NOT FOR BIDDING PURPOSES

1.9 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two (2) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.2 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; by Schneider Electric. (Basis of Design)
2. Eaton.
3. ABB
4. SIEMENS Industry, Inc.; Energy Management Division.

B. Type HD, Heavy Duty:

1. Single throw.
2. Three pole.
3. 240 or 600-V ac.
4. 1200 A and smaller.

NOT FOR BIDDING PURPOSES

5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses.
6. Lockable handle with capability to accept three padlocks and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.3 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; by Schneider Electric. (Basis of Design)
2. Eaton.
3. ABB
4. SIEMENS Industry, Inc.; Energy Management Division.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 240 or 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

NOT FOR BIDDING PURPOSES

2.4 ELEVATOR MAIN LINE (MOTOR) DISCONNECT SWITCH

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton. (Basis of Design)
2. Square D; by Schneider Electric.
3. ABB
4. SIEMENS Industry, Inc.; Energy Management Division.

B. Elevator Main Line (Motor) Disconnect Switch shall be an Elevator Control Switch, which switch shall include fused disconnect switch (provide class J fuses as recommended by elevator manufacturer) with provisions for locking in the open position only; 120 volt secondary control power transformer with primary and secondary fusing; fire alarm voltage monitoring relay for monitoring of control voltage, per NFPA-72 paragraph 3-9.4; fire safety interface relay; shunt trip device; green power on pilot light; key operated test switch; auxiliary contacts; and NEMA 1 enclosure. Elevator control switch shall be Eaton series ES which shall form the basis of design. Make all final connections to Elevator controller line-in (power) terminals, to fire alarm system for shunt trip, for control voltage monitoring, and to elevator emergency battery automatic return unit.

2.5 SHUNT TRIP SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bussmann, an Eaton business.
2. Littelfuse, Inc.
3. Mersen USA.

B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.

C. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch: 240 or 600-V ac, 30, 60, or 100 A; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, with clips or bolt pads to accommodate indicated fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Type HD, Heavy-Duty, Three Pole, Single-Throw Nonfusible Switch: 240 or 600-V ac, 30, 60, or 100 A; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

E. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power source of enough capacity to operate shunt trip, pilot, indicating and control devices.

F. Accessories:

1. Oiltight key switch for key-to-test function.
2. Oiltight red and green ON pilot light.

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3. Isolated neutral lug; 100 percent rating.
4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
5. Form C alarm contacts that change state when switch is tripped.
6. Three-pole, double-throw, fire-safety and alarm relay; 120-V ac coil voltage.
7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.
8. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
9. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
10. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
11. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac.
12. Hookstick Handle: Allows use of a hookstick to operate the handle.
13. Lugs: Mechanical type, suitable for number, size, and conductor material.
14. Service-Rated Switches: Labeled for use as service equipment.

2.6 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; by Schneider Electric. (Basis of Design)
2. Eaton.
3. ABB
4. SIEMENS Industry, Inc.; Energy Management Division.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated. Circuit breaker/circuit breaker combinations for series connected interrupting ratings shall be listed by UL as recognized component combinations. Any series rated combination used shall be marked on the end-use equipment along with the statement "Caution - Series Rated System. Identical Replacement Component Required.

E. MCCBs shall be equipped with a device for locking in the isolated position.

F. Lugs shall be suitable for 140 deg F rated wire on 125-A circuit breakers and below.

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G. Standard: Comply with UL 489, with interrupting capacity to comply with available fault currents.

H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I-squared t response.

K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

L. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

M. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

N. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

O. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system, specified in Section 260913 "Electrical Power Monitoring and Control."
6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
8. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.

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10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
11. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
12. Electrical Operator: Provide remote control for on, off, and reset operations.
13. Accessory Control Power Voltage: Integrally mounted, self-powered; 24-V ac.

2.7 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; by Schneider Electric. (Basis of Design)
2. Eaton.
3. ABB
4. SIEMENS Industry, Inc.; Energy Management Division.

B. Description: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

D. Features and Accessories:

1. Standard frame sizes and number of poles.
2. Lugs:
    a. Mechanical type, suitable for number, size, trip ratings, and conductor material.
    b. Lugs shall be suitable for 140 deg F rated wire on 125-A circuit breakers and below.
3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NO contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered; 24-V ac.

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2.8 ARC-FLASH LIMITING FEEDER CIRCUIT BREAKERS

A. Feeder circuit breakers shall be without current-limiting fuses, listed as complying with UL 1066.

B. Short-circuit withstand current rating shall be 200 kA.

C. Equip the arc-flash limiting feeder circuit breakers with Arc-Flash Maintenance Setting switch for use as a temporary arc-flash incident energy-reduction device during maintenance activities on that feeder.

1. Provide a manual switch on the compartment door to switch the circuit-breaker short-time tripping characteristics to instantaneous with minimum pickup setting, to reduce the danger from potential arc-flash at downstream equipment.
2. Provide a lock feature for the switch so that it may be locked in either the off or on maintenance-mode position.
3. Provide a blue LED indicating light to indicate that the switch is in maintenance mode.
4. Provide dry relay contacts on each switch for annunciation of the switch position.

2.9 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1), gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (NEMA 250 Types 3R, and a brush finish on Type 304 stainless steel (NEMA 250 Type 4-4X stainless steel).

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be directly operable through the front cover of the enclosure (NEMA 250 Type 1) and directly operable through the dead front trim of the enclosure (NEMA 250 Type 3R). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 ELEVATOR CONNECTIONS

A. All electrical work associated with the elevator(s) shall be in strict accordance with AMSE/ANSI A17.1, Safety Code for Elevators and Escalators (latest edition) and National Electrical Code Article 620, Elevators, Dumbwaiters, Escalators, Moving Walks, Platform Lifts, and Stairway Chairlifts, including interpretations of local and third party inspection agencies.

B. All disconnect switches associated with the elevator equipment shall be able to be padlocked in the Open position only. Disconnect switches which can be padlocked in the closed position, or which can be padlocked so as to prevent being opened are not acceptable.

C. Where elevator shafts, pits, and control rooms are equipped with sprinklers, all circuits serving elevator equipment shall be equipped with shunt trips, which automatically shut down power to the elevator equipment prior to the application of water from the sprinklers. Shunt trips shall be activated by the building fire alarm system on activation of heat detectors, located within 12” of any sprinkler head located in the elevator shaft, pit, or control room. The control voltage to actuate the shunt trips shall be derived from the Elevator Main Line (Motor) Disconnect Switch. Provide fused tap within Elevator Main Line (Motor) Disconnect Switch, with control power transformer to provide 120 volt power for shunt trips.

3.3 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NFPA 70 and NECA 1.

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3.4 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and clearances.
c. Verify that the unit is clean.
d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
e. Verify that fuse sizes and types match the Specifications and Drawings.
f. Verify that each fuse has adequate mechanical support and contact integrity.
g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
i. Verify correct phase barrier installation.
j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

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2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

F. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify that the unit is clean.
e. Operate the circuit breaker to ensure smooth operation.
f. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and chutes in unsealed units.
h. Perform adjustments for final protective device settings in accordance with the coordination study.

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2. Electrical Tests:

   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
   c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.
   e. Determine the following by primary current injection:

      1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
      2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
      3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
      4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

   f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.
   g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.
   h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
   i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
4. Perform the following infrared scan tests and inspections and prepare reports:

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a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

G. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

H. Prepare test and inspection reports.

1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

END OF SECTION 26 28 16

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SECTION 26 29 13.03

MANUAL AND MAGNETIC MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Manual motor controllers.
2. Enclosed full-voltage magnetic motor controllers.
3. Combination full-voltage magnetic motor controllers.
4. Enclosures.
5. Accessories.
6. Identification.

1.3 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. NC: Normally closed.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SCPD: Short-circuit protective device.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type of magnetic controller.

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1. Include plans, elevations, sections, and mounting details.
2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
3. Wire Termination Diagrams and Schedules: Include diagrams for signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Product Schedule: List the following for each enclosed controller:

1. Each installed magnetic controller type.
2. NRTL listing.
3. Factory-installed accessories.
4. Nameplate legends.
5. SCCR of integrated unit.
6. For each combination magnetic controller include features, characteristics, ratings, and factory setting of the SCPD and OCPD.

    a. Listing document proving Type 2 coordination.

7. For each series-rated combination state the listed integrated short-circuit current (withstand) rating of SCPD and OCPDs by an NRTL acceptable to authorities having jurisdiction.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For magnetic controllers to include in operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

    a. Routine maintenance requirements for magnetic controllers and installed components.
    b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
    c. Manufacturer's written instructions for setting field-adjustable overload relays.
    d. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

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e. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.10 FIELD CONDITIONS

A. Ambient Environment Ratings: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than 23 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet for electromagnetic and manual devices.
3. The effect of solar radiation is not significant.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

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B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.

C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

2.2 MANUAL MOTOR CONTROLLERS

A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Square D; Schneider Electric USA. (Basis of Design)
    b. ABB, Motion Business.
    c. Eaton.
    d. Siemens Industry, Inc., Energy Management Division.

2. Standard: Comply with NEMA ICS 2, general purpose, Class A.
3. Configuration: Nonreversing.
4. Surface mounting.
5. Red and Green pilot light.

B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Square D; Schneider Electric USA. (Basis of Design)
    b. ABB, Electrification Business.
    c. ABB, Motion Business.
    d. Eaton.
    e. Siemens Industry, Inc., Energy Management Division.

2. Configuration: Nonreversing.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
4. Overload Relays: NEMA ICS 2, bimetallic class as schedule on Drawings.
5. Pilot Light: Red.

C. Integral Horsepower Manual Controllers (IHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Square D; Schneider Electric USA. (Basis of Design)
    b. ABB, Electrification Business.

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c. ABB, Motion Business.
d. Eaton.
e. Siemens Industry, Inc., Energy Management Division.

2. Configuration: Nonreversing.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
4. Overload Relays: NEMA ICS 2, bimetallic class as scheduled on Drawings.

2.3 ENCLOSED FULL-VOLTAGE MAGNETIC MOTOR CONTROLLERS

A. Description: Across-the-line start, electrically held, for nominal system voltage of 600-V ac and less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; Schneider Electric USA. (Basis of Design)
2. ABB, Electrification Business.
3. ABB, Motion Business.
4. Eaton.
5. Siemens Industry, Inc., Energy Management Division.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: Nonreversing.

E. Contactor Coils: Pressure-encapsulated type with coil transient suppressors when indicated.

1. Operating Voltage: Manufacturer's standard, unless indicated.

F. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.

a. Spare CPT Capacity as Indicated on Drawings: 50 VA.

G. Overload Relays:

1. Thermal Overload Relays:

a. Inverse-time-current characteristic.
b. Class 10 tripping characteristic.
c. Heaters in each phase shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.
e. Automatic resetting.

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2. Solid-State Overload Relay:

a. Switch or dial selectable for motor-running overload protection.
b. Sensors in each phase.
c. Class 10 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
d. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

H. Digital communication module, using RS-485 Modbus, RTU protocol, 4-wire connection to host devices with a compatible port to transmit the following to the LAN:

1. Instantaneous rms current each phase, and 3-phase average.
2. Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
3. Active Energy (kWh): 3-phase total.
4. Power Factor: Each phase and 3-phase total.

2.4 COMBINATION FULL-VOLTAGE MAGNETIC MOTOR CONTROLLER

A. Description: Factory-assembled, combination full-voltage magnetic motor controller consisting of the controller described in this article, indicated disconnecting means, SCPD and OCPD, in a single enclosure.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; Schneider Electric USA. (Basis of Design)
2. ABB, Electrification Business.
3. ABB, Motion Business.
4. Eaton.
5. Siemens Industry, Inc., Energy Management Division.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: Nonreversing.

E. Contactor Coils: Pressure-encapsulated type with coil transient suppressors when indicated.

1. Operating Voltage: Manufacturer's standard, unless indicated.

F. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.

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a. Spare CPT Capacity as Indicated on Drawings: 50 VA.

G. Overload Relays:

1. Thermal Overload Relays:

a. Inverse-time-current characteristic.
b. Class 10 tripping characteristic.
c. Heaters in each phase shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

2. Solid-State Overload Relay:

a. Switch or dial selectable for motor-running overload protection.
b. Sensors in each phase.
c. Class 10 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

H. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

I. Digital communication module, using RS-485 Modbus, RTU protocol, 4-wire connection to host devices with a compatible port to transmit the following to the LAN:

1. Instantaneous rms current each phase, and 3-phase average.
2. Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
3. Active Energy (kWh): 3-phase total.
4. Power Factor: Each phase and 3-phase total.

J. Fusible Disconnecting Means:

1. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

K. Nonfusible Disconnecting Means:

1. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

L. MCP Disconnecting Means:

1. UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

M. MCCB Disconnecting Means:

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1. UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse-time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
2. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
3. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

2.5 ENCLOSURES

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.

B. The construction of the enclosures shall comply with NEMA ICS 6.

C. Controllers in hazardous (classified) locations shall comply with UL 1203.

2.6 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, except as needed to match enclosure type. Heavy-duty or oil-tight where indicated in the controller schedule.

   a. Push Buttons: As indicated in the controller schedule.
   b. Pilot Lights: As indicated in the controller schedule.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; resettable.
3. Meters: Panel type, 2-1/2-inch minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.

B. Motor protection relays shall be with solid-state sensing circuit and isolated output contacts for hardwired connections.

1. Phase-failure.
2. Phase-reversal, with bicolor LED to indicate normal and fault conditions. Automatic reset when phase reversal is corrected.
3. Under/overvoltage, operate when the circuit voltage reaches a preset value, and drop out when the operating voltage drops to a level below the preset value. Include adjustable time-delay setting.

C. Breather assemblies, to maintain interior pressure and release condensation in Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

D. Space heaters, with NC auxiliary contacts, to mitigate condensation in Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

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E. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

2.7 IDENTIFICATION

A. Controller Nameplates: as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels:

1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.
2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

a. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1) Location designation.
2) Nominal voltage.
3) Flash protection boundary.
4) Hazard risk category.
5) Incident energy.
6) Working distance.
7) Engineering report number, revision number, and issue date.

b. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems" unless otherwise indicated.

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C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
2. Visual and Mechanical Inspection:

    a. Compare equipment nameplate data with drawings and specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify the unit is clean.
    e. Inspect contactors:

        1) Verify mechanical operation.
        2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.

    f. Motor-Running Protection:

        1) Verify overload element rating is correct for its application.
        2) If motor-running protection is provided by fuses, verify correct fuse rating.

    g. Inspect bolted electrical connections for high resistance using one of the two following methods:

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1) Use a low-resistance ohmmeter. Compare bolted connection resistance values with values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

3. Electrical Tests:

a. For the contactor and circuit breaker, perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Insulation-resistance values shall be according to manufacturer's published data or NETA ATS Table 100.1. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than those of this table or manufacturer's recommendations shall be investigated and corrected.
b. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
c. Test motor protection devices according to manufacturer's published data.
d. Test circuit breakers as follows:

1) Operate the circuit breaker to ensure smooth operation.
2) For adjustable circuit breakers, adjust protective device settings according to the coordination study. Comply with coordination study recommendations.

e. Perform operational tests by initiating control devices.

4. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove all necessary covers prior to the inspection.

a. Comply with the recommendations of NFPA 70B, "Testing and Test Methods" Chapter, "Infrared Inspection" Article.
b. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of each motor controller.
c. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each motor controller 11 months after date of Substantial Completion.
d. Report of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used, and lists the following results:

1) Description of equipment to be tested.
2) Discrepancies.
3) Temperature difference between the area of concern and the reference area.
4) Probable cause of temperature difference.

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5) Areas inspected. Identify inaccessible and unobservable areas and equipment.
6) Load conditions at time of inspection.
7) Photographs and thermograms of the deficient area.
8) Recommended action.

e. Equipment: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C. The equipment shall detect emitted radiation and convert detected radiation to a visual signal.

f. Act on inspection results and recommended action, and considering the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

E. Motor controller will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

B. Motor controller will be considered defective if it does not pass the system function tests and inspections.

C. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION 26 29 13.03

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SECTION 26 29 13.06

SOFT-START MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes soft-start motor controllers that are designed for reduced-voltage start and full-voltage run duty.

1. Enclosed soft-start controllers.
2. Combination soft-start controllers.
3. Enclosures.
4. Accessories.
5. Identification.

1.3 DEFINITIONS

A. CPT: Control power transformer.

B. FLA: Full-load current.

C. MCCB: Molded-case circuit breaker.

D. MCP: Motor circuit protector.

E. NC: Normally closed.

F. NO: Normally open.

G. OCPD: Overcurrent protective device.

H. SCCR: Short-circuit current rating.

I. SCPD: Short-circuit protective device.

J. SCR: Silicon-controlled rectifier.

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1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type of controller.

1. Include plans, elevations, sections, and mounting details.
2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
3. Wire Termination Diagrams and Schedules: Include diagrams for signal and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include features, characteristics, ratings, and factory settings of individual OCPD and auxiliary components.

C. Product Schedule: For each enclosed controller.

1. Each installed soft-start controller type.
2. NRTL listing.
3. Factory-installed accessories.
4. Nameplate legends.
5. SCCR of integrated unit.

a. For each combination soft-start controller, include features, characteristics, ratings, and factory setting of the SCPD and OCPD.

1) Listing document proving Type 2 coordination.

b. For each series-rated combination, state the listed integrated SCCR (withstand) of SCPDs and OCPDs by an NRTL acceptable to authorities having jurisdiction.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Source quality-control reports.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For soft-start controllers to include in operation and maintenance manuals.

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1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

    a. Routine maintenance requirements for soft-start controllers and installed components.
    b. Manufacturer's written instructions for testing and adjusting circuit-breaker and MCP trip settings.
    c. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage soft-start controllers.
    d. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate FLAs.
    e. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Store soft-start controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect soft-start controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.10 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

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1. Ambient Temperature: Not less than 32 deg F and not exceeding 104 deg F, humidity noncondensing.
2. Altitude: Not exceeding 3300 feet.
3. The effect of solar radiation is insignificant.

PART 2 - PRODUCTS

2.1 MOTOR CONTROLLER PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. UL Compliance: Fabricate and label enclosed controllers to comply with UL 508.

C. NEMA Compliance: Fabricate motor controllers to comply with NEMA ICS 2.

2.2 ENCLOSED SOFT-START MOTOR CONTROLLERS

A. Description: Controllers designed for reduced-voltage start, full-voltage run, and optional soft stop. The controller shall be an integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and user interface module, run-bypass contactor, and overload relay(s); suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

1. Run-Bypass Contactor: Magnetic contactor in parallel with the SCR of the soft-start controller, bypassing the SCR when full voltage is achieved.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; Schneider Electric USA. (Basis of Design)
2. ABB, Electrification Business.
3. ABB, Motion Business.
4. Eaton.
5. Siemens Industry, Inc., Energy Management Division.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: Standard duty.

1. At least two SCRs per phase to control the starting and stopping of the motor.
2. Microprocessor control shall continuously monitor current and proper operation of the SCRs.
3. Bypass Contactor: Operates automatically when full voltage is applied to motor and bypasses the SCRs. Soft-start controller protective features and deceleration controls shall remain active when this contactor is in the bypass mode.
4. Power Electronics Disconnect Contactor. Where indicated, installed ahead of the power electronics equipment, and shall open automatically when the motor is stopped, or a controller fault is detected, or when an SCR shorts.

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5. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
6. Surge Protection: Comply with NEMA ICS 2 requirements for surge suppression.

E. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.
2. Spare CPT Capacity: As indicated on Drawings, available in increments of 100 VA, from 100 to 500 VA.

F. Controller Diagnostics and Protection:

1. Microprocessor-based thermal-protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
2. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and under-load conditions; and line frequency over or under normal.
3. Input isolation contactor that opens when the controller diagnostics detect a faulted soft-start component or when the motor is stopped.

G. Cover mounted-controller status panel with LED lights or alphanumeric display to show the following:

1. Starter Status: "Ready," "starting," "stopping," or "run."
2. Motor current in amperes.
3. Faults:

    a. Motor overcurrent trip.
    b. Motor thermal overload.
    c. Starter thermal fault.
    d. Low line voltage.
    e. Loss of a phase.
    f. Phases reversed.
    g. Maximum stating time exceeded.
    h. Serial communications error.

H. Interface Panel: Mounted on controller door.

1. Guarded adjustable set points, not readily accessible.

    a. Motor FLA, adjustable from 40 to 110 percent of the controller's rating.
    b. Current limitation on starting, adjustable from 200 to 500 percent of FLA, typically set at 300 percent.
    c. NEMA ICS 2 overload class. Selections shall include the following tripping classes: Class 5, Class 10, Class 15, Class 20, and Class 30.

2. Adjustable set points, readily accessible, password protected.

    a. Linear acceleration, adjustable from 1 to 60 s.

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b. Maximum start time, adjustable from 1 to 250 s.
c. Selector switch: select coast to stop or soft stop.
d. Linear deceleration, adjustable from 1 to 60 s.

I. Remote Output Features. All outputs shall be prewired to terminal blocks.

1. Analog output for field-selectable assignment of motor operating characteristics; 0- to 10-V dc.
2. Form C status contacts that change state when controller is running.
3. Form C alarm contacts that change state when a fault condition occurs.

J. Digital Communication Module: RS-485 Modbus, RTU protocol, 4-wire connection to host devices with a compatible port to transmit the following to the LAN:

1. Instantaneous root mean square (rms) current each phase, and three-phase average.
2. Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average - rms.
3. Active Energy (kilowatt-hour): Three-phase total.
4. Power Factor: Each phase and three-phase total.
5. <Insert value>.

2.3 COMBINATION SOFT-START MOTOR CONTROLLERS

A. Description: Factory-assembled, combination, reduced-voltage soft-start controller with a disconnecting means, SCPD and OCPD, in a single enclosure. The reduced-voltage soft-start controller shall consist of an integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and user interface module, run-bypass contactor, and overload relay(s); suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

1. Run-Bypass Contactor: Magnetic contactor in parallel with the SCR of the soft-start controller, bypassing the SCR when full voltage is achieved.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; Schneider Electric USA. (Basis of Design)
2. ABB, Electrification Business.
3. ABB, Motion Business.
4. Eaton.
5. Siemens Industry, Inc., Energy Management Division.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: Standard duty.

1. At least two SCRs per phase to control the starting and stopping of the motor.
2. Microprocessor control shall continuously monitor current and proper operation of the SCRs.

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3. Bypass Contactor: Operates automatically when full voltage is applied to motor and bypasses the SCRs. Soft-start controller protective features and deceleration controls shall remain active when this contactor is in the bypass mode.
4. Power Electronics Disconnect Contactor. Where indicated, installed ahead of the power electronics equipment, and shall open automatically when the motor is stopped, or a controller fault is detected, or when an SCR shorts.
5. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
6. Surge Protection: Comply with NEMA ICS 2 requirements for surge suppression.

E. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.
2. Spare CPT Capacity: As indicated on Drawings, available in increments of 100 VA, from 100 to 500 VA.

F. Controller Diagnostics and Protection:

1. Microprocessor-based thermal-protection system for monitoring SCR and motor thermal characteristics and providing controller overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
2. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and under-load conditions; and line frequency over or under normal.
3. Input isolation contactor that opens when the controller diagnostics detect a faulted soft-start component or when the motor is stopped.

G. Cover mounted-controller status panel with LED lights or alphanumeric display to show the following:

1. Starter Status: "Ready," "starting," "stopping," or "run."
2. Motor current in amperes.
3. Faults:

   a. Motor overcurrent trip.
   b. Motor thermal overload.
   c. Starter thermal fault.
   d. Low line voltage.
   e. Loss of a phase.
   f. Phases reversed.
   g. Maximum stating time exceeded.
   h. Serial communications error.

H. Interface Panel: Mounted on controller door.

1. Guarded adjustable set points, not readily accessible.

   a. Motor FLA, adjustable from 40 to 110 percent of the controller's rating.
   b. Current limitation on starting, adjustable from 200 to 500 percent of FLA, typically set at 300 percent.

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c. NEMA ICS 2 overload class. Selections shall include the following tripping classes: Class 5, Class 10, Class 15, Class 20, and Class 30.

2. Adjustable set points, readily accessible, password protected.

a. Linear acceleration, adjustable from 1 to 60 s.
b. Maximum start time, adjustable from 1 to 250 s.
c. Selector switch: select coast to stop or soft stop.
d. Linear deceleration, adjustable from 1 to 60 s.

I. Remote Output Features: All outputs shall be prewired to terminal blocks.

1. Analog output for field-selectable assignment of motor operating characteristics; 0- to 10-V dc.
2. Form C status contacts that change state when controller is running.
3. Form C alarm contacts that change state when a fault condition occurs.

J. Digital Communication Module: RS-485 Modbus, RTU protocol, 4-wire connection to host devices with a compatible port to transmit the following to the LAN:

1. Instantaneous rms current each phase, and three-phase average.
2. Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average - rms.
3. Active Energy (kilowatt-hour): Three-phase total.
4. Power Factor: Each phase and three-phase total.

K. Fusible Disconnecting Means:

1. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J and Class L fuses.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.

L. MCP Disconnecting Means:

1. UL 489 and NEMA AB 3 (with interrupting capacity to comply with available fault currents) instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
4. NO alarm contact that operates only when MCP has tripped.

a. Current-limiting module to increase controller SCCR (withstand) to 100 kA.

M. MCCB Disconnecting Means:

1. UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
2. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

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3. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
4. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
5. NO alarm contact that operates only when MCCB has tripped.

N. Molded-Case Switch Disconnecting Means:

1. UL 489 and NEMA AB 3, with in-line fuse block for Class J or Class L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3. Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
4. NO alarm contact that operates only when molded-case switch has tripped.

2.4 ENCLOSURES

A. Comply with NEMA 250, Type designations as indicated on Drawings, to comply with environmental conditions at installed location.

B. Construction of the enclosures shall comply with NEMA ICS 6.

C. Controllers in hazardous (classified) locations shall comply with UL 1203.

2.5 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Standard duty, except as needed to match enclosure type. Heavy-duty or oiltight where indicated in the controller schedule.

a. Push Buttons: As indicated in the controller schedule.
b. Pilot Lights: As indicated in the controller schedule.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; resettable.
3. Meters: Panel type, 2-1/2-inch minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy. Where indicated, provide selector switches with an off position.

B. Breather assemblies, to maintain interior pressure and release condensation in Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

C. Space heaters, with NC auxiliary contacts, to mitigate condensation in Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

D. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

NOT FOR BIDDING PURPOSES

2.6 IDENTIFICATION

A. Controller Nameplates: signs, as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels:

1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3-1/2-by-5-inch self-adhesive label for each work location included in the analysis.
2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3-1/2-by-5-inch self-adhesive equipment label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

a. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1) Location designation.
2) Nominal voltage.
3) Flash protection boundary.
4) Hazard risk category.
5) Incident energy.
6) Working distance.
7) Engineering report number, revision number, and issue date.

b. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on slotted support systems complying with Section 260529 "Hangers and Supports for Electrical Systems," and bolted to wall.

C. Freestanding Controllers: Provide slotted support systems complying with Section 260529 "Hangers and Supports for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

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E. Control Wiring: Separate control wiring from power wiring. Where unavoidable, use twisted pair cabling or shielded cables for control wiring.

F. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

G. Setting of Overload Relays: Select and set overloads on the basis of FLA rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for high-torque, high-efficiency, and so on motors.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Comply with provisions of NFPA 70B, Chapter "Testing and Test Methods."
2. Visual and Mechanical Inspection:

    a. Compare equipment nameplate data with Drawings and the Specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify that the unit is clean.
    e. Ensure that vent path openings are free from debris and that heat-transfer surfaces are clean.
    f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
    g. Inspect Contactors:

        1) Verify mechanical operation.
        2) Verify that contact gap, wipe, alignment, and pressure are according to manufacturer's published data.

    h. Motor-Running Protection:

        1) Verify that motor FLA is at, or under, the controller current rating.
        2) Verify that overload element setting is correct for its application.
        3) Apply minimum- and maximum-speed set points. Verify that set points are within limitations of the load coupled to the motor.

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4) If motor-running protection is provided by fuses, verify correct fuse rating.

i. Inspect bolted electrical connections for high resistance using one of the following two methods:

1) Use a low-resistance ohmmeter. Compare bolted-connection-resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

3. Electrical Tests:

a. For the contactor and circuit breaker, perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Insulation-resistance values shall be according to manufacturer's published data or NETA ATS, Table 100.1. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than this table or manufacturer's written instructions shall be investigated and corrected.
b. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
c. Test motor protection devices according to manufacturer's published data.
d. Test circuit breakers as follows:

1) Operate the circuit breaker to ensure smooth operation.
2) For adjustable circuit breakers, adjust protective device settings according to the coordination study. Comply with coordination study recommendations.

e. Test the electronic motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
f. Test the following parameters according to NETA relay calibration procedures, or as recommended by manufacturer:

1) ANSI No. 49R, Overtemperature Protection:

a) Determine time delay at 300 percent of setting.
b) Determine a second point on the operating curve.
c) Determine pickup.

2) ANSI No. 47, Input Phase Loss and Reversed Phases Protection:

a) Determine positive sequence voltage to close the NO contact.

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b) Determine positive sequence voltage to open the NC contact (undervoltage trip).
c) Verify negative sequence trip.
d) Determine time delay to close the NO contact with sudden application of 120 percent of pickup.
e) Determine time delay to close the NC contact on removal of voltage when previously set to rated system voltage.

3) ANSI No. 81, Overfrequency Protection:

a) Verify frequency set points.
b) Determine time delay.
c) Determine undervoltage cutoff.

4) Fault Alarm Outputs: Verify that each relay contact performs its intended function in the control scheme including breaker trip tests, close inhibit tests, lockout tests, and alarm functions.

g. Perform operational tests by initiating control devices.

4. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove all necessary covers prior to the inspection.

a. Comply with recommendations of NFPA 70B, Chapter "Testing and Test Methods," Article "Infrared Inspection."
b. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of each motor controller.
c. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each motor controller 11 months after date of Substantial Completion.
d. Report of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used, and lists the following results:

1) Description of equipment to be tested.
2) Discrepancies.
3) Temperature difference between the area of concern and the reference area.
4) Probable cause of temperature difference.
5) Areas inspected. Identify inaccessible and unobservable areas and equipment.
6) Identify load conditions at time of inspection.
7) Provide photographs and thermograms of the deficient area.
8) Recommended action.

e. Equipment: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C. The equipment shall detect emitted radiation and convert detected radiation to a visual signal.
f. Act on inspection results, recommended action, and considering recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

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E. Motor controllers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality-control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

B. Motor controllers will be considered defective if they do not pass the system function tests and inspections.

C. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain motor controllers.

END OF SECTION 26 29 13.06

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SECTION 26 32 13.13

DIESEL-ENGINE-DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Diesel-engine-driven generator sets.
2. Diesel engine.
3. Diesel fuel-oil system.
4. Control and monitoring.
5. Generator overcurrent and fault protection.
6. Generator, exciter, and voltage regulator.
7. Outdoor engine generator enclosure.
8. Vibration isolation devices.
9. Unit mounted auxiliary power load center

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.2 DESCRIPTION OF SYSTEM AND SITE

A. Provide a 2,400-kW integrated, standby power system to supply electrical power at 277/480 Volts, 60 Hertz, 3 Phase. The system will utilize a total of four (4) generators rated at 600 kW/750 kVA. The generator shall consist of a liquid cooled diesel engine, a synchronous AC alternator, and system controls with all necessary accessories for a complete operating system, including but not limited to the items as specified hereinafter.

B. The site is an NEC ordinary location with no specific harsh environment requirements.

C. The genset shall be applied at the listed ambient and elevation. Bidders to submit the generators rated power output at 104 ambient (˚F) and 500 elevation (Ft).

D. Bidders are to submit the genset's sound level in dBA at 23 ft based on the configuration specified.

1.3 REQUIREMENTS OF REGULATORY AGENCIES

A. An electric generating system, consisting of a prime mover, generator, governor, coupling and all controls, must have been tested, as a complete unit, on a representative engineering prototype model of the equipment to be sold.

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B. The generator set must conform to applicable NFPA requirements.

C. The generator set must include a listing for the UL2200 standard for stationary engine generator assembly.

D. The generator set must meet EPA federal emission guidelines for stationary emergency power generation.

1.4 MANUFACTURER QUALIFICATIONS

A. This system shall be supplied by an original equipment manufacturer (OEM) who has been regularly engaged in the production of engine-alternator sets, automatic transfer switches, and associated controls for a minimum of 25 years, thereby identifying one source of supply and responsibility.

B. The manufacturer shall have printed literature and brochures describing the standard series specified, not a one of a kind fabrication.

C. Manufacturer's authorized service representative shall meet the following criteria:

1. Certified, factory trained, industrial generator technicians
2. Service support 24/7
3. Service location within 200 miles
4. Response time of four hours
5. Service and repair parts in-stock at performance level of 95 percent

1.5 DEFINITIONS

A. EPS: Emergency power supply.

1.6 EPSS: Emergency power supply system

1.7 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.
4. Include fuel consumption in gallons per hour at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include airflow requirements for cooling and combustion air in cubic feet per minute at 0.8 power factor, with air-supply temperature of 95, 80, 70, and 50 deg F. Provide Drawings indicating requirements and limitations for location of air intake and exhausts.

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7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for engine generators and functional relationship between all electrical components.

1.8 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, manufacturer, and testing agency.

B. Source Quality-Control Reports: Including, but not limited to, the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

C. Field quality-control reports.

D. Warranty statement.

1.9 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

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a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
b. Operating instructions laminated and mounted adjacent to generator location.
c. Training plan.

1.10 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.11 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.12 PERMITS, FILINGS AND MISCELLANEOUS REGULATORY REQUIREMENTS:

A. File for and obtain all required Federal, State and local environmental, air quality, and other specialty permits, registrations, and other regulatory requirements for the installation of the generator, generator exhaust system, generator fuel supply and storage system, and other generator system components. All such filings shall be made on behalf of and in the name of the Owner. Provide copies of all such submissions to the Owner and to the Engineer for their record.

B. Compile all such submissions and certifications in a separate 3-ring binder similar to those used for the project Operation and Maintenance Manuals. Include a schedule of required resubmission and renewal dates for the Owner’s guidance and information. This shall include all required forms, and the agency, including proper filing address, to which the renewals must be submitted. The schedule shall be for a minimum duration of five (5) years from the date of project Substantial Completion.

C. All costs for such regulatory filings shall be included in the project bid.

1.13 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace complete genset, components of packaged engine generators, instrumentation panels, controls, associated

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auxiliary components, associated switches, load shed controller, exhaust systems, enclosures, and sub-base fuel tanks, that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from the date of final commissioning against defects in materials and workmanship. Coverage shall include parts, travel expenses, and labor to remove/reinstall the equipment, per the manufacturer's standard published warranty. There shall be no deductibles applied to the warranty.

B. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, etc.

C. The manufacturer supplying the warranty for the complete system must have the necessary financial strength and technical expertise with all components supplied to provide adequate warranty support.

1.14 FUEL

A. Prior to start-up of the generators, coordinate with the State Contracted Company for filling of each entire generator fuel oil system including all tanks, fuel oil piping, etc., to its full capacity, with fuel meeting all generator manufacturer's recommendations.

B. Coordinate all required fuel with the State Contracted Company, in accordance with generator set manufacturer's recommendations, for all testing, re-testing, demonstrations, commissioning, instruction sessions, etc.

C. Upon completion of all testing, demonstrations, etc. coordinate with the State Contracted Company for re-filling of each generator fuel oil system to provide a full supply of fuel for the entire generator system.

PART 2 - PRODUCTS

2.1 DIESEL-ENGINE-DRIVEN GENERATOR SETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Generac Industrial Power. (Basis of Design)
2. Cummins Power Generation.
3. Caterpillar, Inc.; Electric Power Division.
4. Kohler Power Systems.

B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. B11 Compliance: Comply with B11.19.

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B. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level 1 EPSS.

C. UL Compliance: Comply with UL 2200.

D. Engine Exhaust Emissions: Comply with EPA emission requirements and applicable state and local government requirements for standby power generation.

E. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

F. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 41 to 104 deg F.
2. Altitude: Sea level to 1000 feet.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Power Rating: Standby.

D. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.

E. EPSS Class: Engine generator shall be classified as a Class 96 according to NFPA 110.

F. Service Load: 750 kVA.

G. Power Factor: 0.8, lagging.

H. Frequency: 60 Hz.

I. Voltage: 480-V ac.

J. Phase: Three-phase, four wire, wye.

K. Induction Method: Turbocharged.

L. Governor: Adjustable isochronous, with speed sensing.

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M. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

N. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

O. Engine Generator Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

    a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

    a. Provide permanent magnet excitation for power source to voltage regulator.

10. Start Time:

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a. Comply with NFPA 110, Type 10 system requirements.

P. Parallel Engine Generators:

1. Automatic reactive output power control and load sharing between engine generators operated in parallel.
2. Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.
3. Protective relays required for equipment and personnel safety.
4. Paralleling suppressors to protect excitation systems.
5. Reverse power protection.
6. Loss of field protection.

2.4 DIESEL ENGINE

A. Fuel: ASTM D975, diesel fuel oil, Grade 2-D S15.

1. The engine fuel system shall be designed for operation on #2 diesel fuel and cold weather diesel blends.

2. The engine shall include a primary fuel filter, water separator, manual fuel priming pump, and engine flexible fuel lines must be installed at the point of manufacture. Element shall be replaceable paper type.

3. The engines suction line shall be fitted with a check valve to secure prime for the engines injection pump.

B. Rated Engine Speed: 1800 rpm.

C. The engine shall have adequate horsepower to achieve rated kW output.

D. The engine shall support a 100 percent load step.

E. The generator system shall support generator start-up and load transfer within 10 seconds.

F. Engine Controls:

1. Engines that are equipped with an electronic engine control module (ECM), shall monitor and control engine functionality and seamlessly integrate with the genset controller through digital communications. ECM monitored parameters shall be integrated into the genset controllers NFPA 110 alarm and warning requirements. All ECM fault codes shall be displayed at the genset controller in standard language – fault code numbers are not acceptable.
2. For engines without ECM functionality or for any additional genset controller monitoring, sensors are to be conditioned to a 4-20ma signal level to enhance noise immunity and all sensor connections shall be sealed to prevent corrosion.
3. Engine speed shall be controlled with an integrated isochronous governor function with no change in alternator frequency from no load to full load. Steady state regulation is to be 0.25 percent.

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G. Lubrication System: Engine or skid-mounted.

1. Full pressure lubrication shall be supplied by a positive displacement lube oil pump. The engine shall have a replaceable oil filter(s) with internal bypass and replaceable element(s).
2. The engine shall operate on mineral based oil. Synthetic oils shall not be required.
3. The oil shall be cooled by an oil cooler which is integrated into the engine system.
4. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
5. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
6. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances. Provide a valved, piped engine lubrication oil drain, piped to a point outside the generator weather-resistant housing readily accessible for maintenance. This drain shall be suitably mounted so as to be free from all vibrational stress. The drain system shall consist of a brass body gate valve at the engine lubrication oil drain outlet, and a section of flexible metal braided hose. The hose shall have an outer braided metal covering and shall be of material which is compatible with lubrication oil. The hose shall be of sufficient length to extend a minimum of 6" beyond the generator concrete pad, and shall be terminated with suitable brass end fittings. Furnish a 2" diameter hole, with plastic or neoprene gasket, through the generator mounting skid for passage of the generator lubrication oil drain line.

H. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499 and with NFPA 110 requirements for Level 1 equipment for heater capacity.

I. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator set mounting frame and integral engine-driven coolant pump.
1. The coolant system shall include a coolant fill box which will provide visual means to determine if the system has adequate coolant level. The radiator shall be designed for operation in 104 degrees F, (40 degrees C) ambient temperature.
2. The engine shall have a unit mounted, thermostatically controlled water jacket heater(s) to aid in quick starting. The wattage shall be as recommended by the manufacturer.
3. Engine coolant and oil drain extensions, equipped with pipe plugs and shut-off valves, must be provided to the outside of the mounting base for cleaner and more convenient engine servicing.
4. A radiator fan guard must be installed for personnel safety that meets UL and OSHA safety requirements.
5. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
6. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
7. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
8. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
9. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.

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a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

J. Muffler/Silencer:

1. The engine exhaust emissions shall meet the EPA emission requirements for standby power generation.

2. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements. The manufacturer shall supply its recommended stainless steel, flexible connector to couple the engine exhaust manifold to the exhaust system. A rain cap will terminate the exhaust pipe after the silencer.

a. Minimum sound attenuation of 25 dB at 500 Hz.
b. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be 78 dBA or less.

3. For gensets in a weather or sound attenuated enclosure, all exhaust piping from the turbo-charger discharge to the silencer shall be thermally wrapped to minimize heat dissipation inside the enclosure.

K. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

L. Starting System: 24-V electric, with negative ground. Starting shall be by a solenoid shift, DC starting system.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: Shall meet NFPA 110 cranking requirements of 90 seconds of total crank time.
4. Battery specifications (type, amp-hour rating, cold cranking amps) to be provided in the submittal.
5. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times without recharging.
6. Battery Cable: Size as recommended by engine manufacturer for cable length required. Include required interconnecting conductors and connection accessories.
7. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
8. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.

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9. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
10. The genset shall have an automatic dual rate, float equalize, 10 amp battery charger. The charger must be protected against a reverse polarity connection. The chargers charging current shall be monitored within the generator controller to support remote monitoring and diagnostics. The battery charger is to be factory installed on the generator set. Due to line voltage drop concerns, a battery charger mounted in the transfer switch will be unacceptable.

2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 37.

B. Piping: Fuel-oil piping shall be Schedule 40 black steel, complying with requirements in Section 231113 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

D. Fuel Filtering: Remove water and contaminants larger than 1 micron.

E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:

1. Tank level indicator.
2. Fuel-Tank Capacity: as recommended by engine manufacturer for an uninterrupted period of 96 hours' operation at 100 percent of rated power output of engine generator system without being refilled.
3. The tank shall include fuel suction and return connections, normal and emergency vents, secondary containment emergency vent and rupture basin sensor, mechanical fuel level indication and a stub-up area convenient for electrical conduit entry.
4. The fuel tank shall use an electric fuel sensor to provide an analog indication of fuel level. The controller shall have a warning indication on low fuel level and provide optional shutdown functionality for low, low fuel level.
5. The fuel tank must be supplied by the engine-generator set manufacturer and be installed before shipment.
6. Leak detection in interstitial space.
7. Vandal-resistant fill cap.
8. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.6 CONTROL AND MONITORING

A. The generator control system shall be a fully integrated microprocessor based control system for standby emergency engine generators meeting all requirements of NFPA 110 level 1.

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B. The generator control system shall be a fully integrated control system enabling remote diagnostics and easy building management integration of all generator functions. The generator controller shall provide integrated and digital control over all generator functions including: bi-fuel control, engine protection, alternator protection, speed governing, voltage regulation and all related generator operations. The generator controller must also provide seamless digital integration with the engine's electronic engine control module (ECM) if so equipped. Generator controller's that utilize separate voltage regulators and speed governors or do not provide seamless integration with the engine management system are considered less desirable.

C. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

D. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

E. Provide minimum run time control set for 15 minutes with override only by operation of a remote emergency-stop switch.

F. Communications shall be supported with building automation via the Modbus protocol without network cards. Optional internet and intranet connectivity shall be available.

G. Circuit boards shall utilize surface mount technology to provide vibration durability. Circuit boards that utilize large capacitors or heat sinks must utilize encapsulation methods to securely support these components.

H. A predictive maintenance algorithm that alarms when maintenance is required. The controller shall have the capability to call out to the local servicing dealer when maintenance is required.

I. Diagnostic capabilities should include time-stamped event and alarm logs, ability to capture operational parameters during events, simultaneous monitoring of all input or output parameters, callout capabilities, support for multi-channel digital strip chart functionality and .2 msec data logging capabilities.

J. In addition to standard NFPA 110 alarms, the application loads should also be protected through instantaneous and steady state protective settings on system voltage, frequency, and power levels.

K. The control system shall provide pre-wired customer use I/O: 4 relay outputs (user definable functions), communications support via RS232 and RS485. Additional I/O must be an available option.

L. Customer I/O shall be software configurable providing full access to all alarm, event, data logging, and shutdown functionality. In addition, custom ladder logic functionality inside the

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generator controller shall be supported to provide application support flexibility. The ladder logic function shall have access to all the controller inputs and customer assignable outputs.

M. The control panel will display all user pertinent unit parameters including: engine and alternator operating conditions; oil pressure and optional oil temperature; coolant temperature and level alarm; fuel level (where applicable); engine speed; DC battery voltage; run time hours; generator voltages, amps, frequency, kilowatts, and power factor; alarm status and current alarm(s) condition per NFPA 110 level 1.

N. Comply with UL 508A.

O. Control and Monitoring Panel:

1. Digital engine generator controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. AC voltmeter, connected to a phase selector switch.
    f. AC ammeter, connected to a phase selector switch.
    g. AC frequency meter.
    h. Generator-voltage adjusting rheostat.

3. Controls and Protective Devices: Controls, shutdown devices, and common alarm indication, including the following:

    a. Cranking control equipment.
    b. Run-Off-Auto switch.
    c. Control switch not in automatic position alarm.
    d. Overcrank alarm.
    e. Overcrank shutdown device.
    f. Low-water temperature alarm.
    g. High engine temperature prealarm.
    h. High engine temperature.
    i. High engine temperature shutdown device.
    j. Overspeed alarm.
    k. Overspeed shutdown device.
    l. Low fuel main tank.

        1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for duration required for the indicated EPSS class.

    m. Coolant low-level alarm.
    n. Coolant low-level shutdown device.
    o. Coolant high-temperature prealarm.
    p. Coolant high-temperature alarm.
    q. Coolant low-temperature alarm.

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r. Coolant high-temperature shutdown device.
s. EPS load indicator.
t. Battery high-voltage alarm.
u. Low cranking voltage alarm.
v. Battery-charger malfunction alarm.
w. Battery low-voltage alarm.
x. Lamp test.
y. Contacts for local and remote common alarm.
z. Low-starting air pressure alarm.
aa. Low-starting hydraulic pressure alarm.
bb. Remote manual stop shutdown device.
cc. Air shutdown damper alarm when used.
dd. Air shutdown damper shutdown device when used.
ee. Generator overcurrent-protective-device not-closed alarm.
ff. Hours of operation.
gg. Engine generator metering, including voltage, current, hertz, kilowatt, kilovolt ampere, and power factor.

P. Engine Generator Metering: Comply with Section 260913 "Electrical Power Monitoring and Control."

Q. Remote Alarm Annunciator: An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Low water-temperature alarm.
3. High engine temperature prealarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low fuel main tank alarm.
8. Low coolant level alarm.
9. Low cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Lamp test.
18. Low-cranking voltage alarm.
19. Generator overcurrent-protective-device not-closed alarm.

R. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

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S. Remote Emergency-Stop Switch: Flush; wall mounted unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.

1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Overcurrent Protective Device:

1. Molded-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:

a. A mainline, thermal magnetic circuit breaker carrying the UL mark shall be factory installed. The breaker shall be rated between 100 to 125% of the rated ampacity of the genset. The line side connections are to be made at the factory. Output lugs shall be provided for load side connections.
b. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
c. Trip Settings: Selected to coordinate with generator thermal damage curve.
d. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
e. Mounting: Adjacent to, or integrated with, control and monitoring panel.

C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

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1. Indicate ground fault with other engine generator alarm indications.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. The alternator shall be a 4-pole, revolving field, stationary armature, synchronous machine. The excitation system shall utilize a brushless exciter with a three phase full wave rectifier assembly protected against abnormal transient conditions by a surge protector. Photo-sensitive components will not be permitted in the rotating exciter.

D. The alternator shall include a permanent magnet generator (PMG) for excitation support. The system shall supply a minimum short circuit support current of 300 percent of the rating (250 percent for 50Hz operation) for 10 seconds.

E. The alternator shall support 1,414 skVA with a maximum voltage dip of 30 percent.

F. Stator-Winding Leads: Three phase alternators shall be 12 lead, broad range capable of supporting voltage reconnection. All leads must be extended into a NEMA 1 connection box for easy termination. A fully rated, isolated neutral connection must be included by the generator set manufacturer.

G. The alternator shall use a single, sealed bearing design. The rotor shall be connected to the engine flywheel using flexible drive disks. The stator shall be direct connected to the engine to ensure permanent alignment.

H. The alternator shall meet temperature rise standards of UL2200 (120 degrees C). The insulation system material shall be class "H" capable of withstanding 150 degrees C temperature rise. The alternator shall be protected against overloads and short circuit conditions by advanced control panel protective functions. The control panel is to provide a time current algorithm that protects the alternator against short circuits. To ensure precision protection and repeatable trip characteristics, these functions must be implemented electronically in the generator control panel -- thermal magnetic breaker implementation are not acceptable.

I. An alternator strip heater shall be installed to prevent moisture condensation from forming on the alternator windings. A tropical coating shall also be applied to the alternator windings to provide additional protection against the entrance of moisture.

J. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

K. Enclosure: Dripproof.

L. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

M. Subtransient Reactance: 12 percent, maximum.

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2.9 OUTDOOR ENGINE GENERATOR ENCLOSURE

A. Description:

1. Vandal-resistant, sound-attenuating, weatherproof steel housing; wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

a. Sound Attenuation Level: 2.
b. The genset shall be packaged with a sound attenuating enclosure, 75DBA @ 23 Feet, full load.

B. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to 100 mph.

C. The enclosure shall be completely lined with sound deadening material. This material must be of a self extinguishing design with a reflective surface for enhanced serviceability.

D. The enclosure shall be made of steel with a minimum thickness of 16 gauge. The enclosure is to have hinged, removable doors to allow access to the engine, alternator and control panel. The hinges shall allow for door fit adjustment. Hinges and all exposed fasteners will be stainless steel or Sermagard coated. The use of pop-rivets weakens the paint system and not allowed on external painted surfaces. Each door will have lockable hardware with identical keys.

E. The enclosure shall be coated with electrostatic applied powder paint, baked and finished to manufacturer's specifications. The color will be manufacturer’s standard.

F. The enclosure shall utilize an upward discharging radiator hood. Due to concerns relative to radiator damage, circulating exhaust, and prevailing winds, equipment without a radiator discharge hood will not be acceptable.

G. The genset silencer shall be mounted on the discharge hood of the enclosure. Due to architectural concerns, silencers mounted on the top of the generator enclosure are not acceptable. Gensets with silencers mounted inside the main generator compartment are acceptable only if the silencer is thermally wrapped to minimize heat stress on the surrounding components.

H. Space Heater: Thermostatically controlled and sized to prevent condensation. 5000W enclosure heater.

I. Lighting: Provide weather-resistant LED lighting with 30 fc average maintained.

J. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.

K. Muffler Location: Within enclosure.

L. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.

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1. Louvers: Fixed-engine, cooling-air inlet and discharge. Stormproof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
3. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.

M. Interior Lights with Switch: Factory-wired, vapor-proof luminaires within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.
2. DC lighting system for operation when remote source and generator are both unavailable.

N. Convenience Outlets: Factory-wired, GFCI. Arrange for external electrical connection.

O. Refer to the electrical site plan for layout of generator platform between each generator.

2.10 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Natural rubber separated by steel shims.
2. The packaging shall not require the addition of external spring isolators.
3. The engine/alternator shall be isolated from the generator frame.

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch-thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment-mounting and -leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum Deflection: 1 inch.

C. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.11 UNIT MOUNTED AUXILIARY POWER LOAD CENTER

A. All ancillary AC devices (block heater, battery charger, alternator strip heater, etc) shall have a dedicated breaker within the load center.

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2.12 FINISHES

A. Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.13 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with IEEE 115 and with NFPA 110, Level 1 Energy Converters.

B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Test generator, exciter, and voltage regulator as a unit.
3. Full load run.
4. Maximum power.
5. Voltage regulation.
6. Transient and steady-state governing.
7. Single-step load pickup.
8. Safety shutdown.
9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
10. Report factory test results within 10 days of completion of test.

2.14 SPARE PARTS

A. Fuses: One spare set for each generator.

B. Filters: One spare set (air, fuel, oil) for each generator.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

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3.2 FACTORY TESTING

A. Before shipment of the equipment, the engine-generator set shall be tested under rated load for performance and proper functioning of control and interfacing circuits. Tests shall include:

1. Verify voltage and frequency stability.
2. Verify transient voltage and frequency dip response.
3. Load test all the generators for two hours.

3.3 INSTALLATION

A. Three (3) sets of owner's manuals specific to the product supplied must accompany delivery of the equipment. General operating instruction, preventive maintenance, wiring diagrams, schematics and parts exploded views specific to this model must be included.

B. Comply with NECA 1 and NECA 404.

C. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

D. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Coordinate size and location of concrete bases for packaged engine generators mounted on grade. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

E. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

F. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
2. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
3. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."

G. Drain Piping: Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
2. Drain piping valves, connectors, and installation requirements are specified in Section 232116 "Hydronic Piping Specialties."

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H. Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.

C. Connect cooling-system water piping to engine generator with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Connect fuel piping to engines with a gate valve and union and flexible connector.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL/STARTUP/COMMISSIONING

A. Testing Agency:

1. Engage a factory-authorized trained service technician/representative to test, inspect, and validate the completed installation of all components, assemblies, and equipment, including connections. The service technician/representative shall perform an initial startup inspection to include all the following as listed below.

B. Tests and Inspections:

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1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.

    a. Visual and Mechanical Inspection:

        1) Compare equipment nameplate data with Drawings and the Specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify that the unit is clean.

    b. Electrical and Mechanical Tests:

        1) Perform insulation-resistance tests according to IEEE 43.

            a) Machines Larger Than 200 hp: Test duration shall be 10 minutes. Calculate polarization index.
            b) Machines 200 hp or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.

        2) Test protective relay devices.
        3) Verify phase rotation, phasing, and synchronized operation as required by the application.
        4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
        5) Perform vibration test for each main bearing cap.
        6) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
3. Ensuring the engine starts (both hot and cold) within the specified time.
4. Verification of engine parameters within specification.
5. Test all automatic shutdowns of the engine-generator.
6. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

    a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    c. Verify acceptance of charge for each element of the battery after discharge.
    d. Verify that measurements are within manufacturer's specifications.

7. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
8. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.

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9. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
10. Perform a load test of the electric plant, ensuring full load frequency and voltage are within specification by using building load.
11. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
12. Noise Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet from edge of the generator enclosure, on the property line, closest location to the new building, closest location to the Candee Building, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest and reinspect as specified above.

I. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

K. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

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3.7 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's authorized service representative. Include quarterly preventive maintenance and exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Parts shall be manufacturer's authorized replacement parts and supplies.

B. Supplier of the genset and associated items shall have permanent service facilities in this trade area. These facilities shall comprise a permanent force of factory trained service personnel on 24 hour call, experienced in servicing this type of equipment, providing warranty and routine maintenance service to afford the owner maximum protection. Delegation of this service responsibility for any of the equipment listed herein will not be considered fulfillment of these specifications. Service contracts shall also be available.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

B. Training is to be supplied by the start-up technician for the end-user during commissioning. The training should cover basic generator operation and common generator issues that can be managed by the end-user.

C. Training is to include manual operation of system.

END OF SECTION 26 32 13.13

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SECTION 26 36 00

TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Contactor-type automatic transfer switches.
2. Transfer switch accessories.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Contactor-type automatic transfer switches.
2. Transfer switch accessories.

B. Product Data Submittals: For each product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

C. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Include material lists for each switch specified.
3. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer-authorized service representative and testing agency.

B. Field quality-control reports.

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1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Features and operating sequences, both automatic and manual.
b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications:

1. Member company of NETA.

a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two (2) years from date of final Commissioning.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NEMA ICS 1.

C. Comply with NFPA 99.

D. Comply with NFPA 110.

E. Comply with UL 1008 unless requirements of these Specifications are stricter.

F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

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G. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
2. Short-time withstand capability for 30 cycles.

H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

K. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

L. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

M. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via frontaccess.

N. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ASCO Power Technologies/Schneider Electric. (Basis of Design)
2. Generac Industrial Power.
3. Cummins Power Generation.

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4. Caterpillar, Inc.; Electric Power Division.
5. ABB, Electrification Business.
6. Eaton.
7. Russelectric, Inc

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: Hard-drawn copper, 98 percent conductivity.
6. Main and Neutral Lugs: Mechanical type.
7. Ground Lugs and Bus-Configured Terminators: Mechanical type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

D. Refer to Schedule of Automatic Transfer Switches on the drawings for transition type required for each Automatic Transfer Switch.

E. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

F. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.

1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
3. Fully automatic break-before-make operation with center off position.

G. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.

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3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.

    a. Initiation occurs without active control of generator.
    b. Automatic transfer-switch controller takes active control of generator to match frequency, phase angle, and voltage.
    c. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.

4. Failure of power source serving load initiates automatic break-before-make transfer.

H. Manual Switch Operation, Load-Breaking: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

I. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

J. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

K. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal and Alternate Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

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10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts:

    a. Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.

L. Large-Motor-Load Power Transfer:

1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
2. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be through wiring external to automatic transfer switch. Provide adjustable time delay between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.
3. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

2.3 TRANSFER SWITCH ACCESSORIES

A. Bypass/Isolation Switches:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Comply with requirements for Level 1 equipment according to NFPA 110.
3. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the

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following features for each combined automatic transfer switch and bypass/isolation switch:

a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
b. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
c. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
d. Transition:

1) Provide closed-transition operation when transferring from main transfer switch to bypass/isolation switch on the same power source.
2) Provide open or closed-transition operation, as indicated in the Schedule of Transfer Switches on the drawings, when transferring between power sources.

e. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
f. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
g. Manual Control: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less. Operating handles shall be externally operated.
h. Automatic and Nonautomatic Control: Automatic transfer-switch controller shall also control the bypass/isolation switch.
i. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
j. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

4. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

B. Remote Annunciator System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches.
3. Annunciation panel display shall include the following indicators:

a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
b. Switch position.
c. Switch in test mode.
d. Failure of communication link.

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4. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

    a. Indicating Lights: Grouped for each transfer switch monitored.
    b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
    c. Mounting: Flush, modular, steel cabinet unless otherwise indicated.
    d. Lamp Test: Push-to-test or lamp-test switch on front panel.

5. Locate adjacent to Generator Annunciators, where shown on the drawings.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for Life Safety (emergency) or Critical systems. Include results of test for the following conditions:

    a. Overvoltage.
    b. Undervoltage.
    c. Loss of supply voltage.
    d. Reduction of supply voltage.
    e. Alternative supply voltage or frequency is at minimum acceptable values.
    f. Temperature rise.
    g. Dielectric voltage-withstand; before and after short-circuit test.
    h. Overload.
    i. Contact opening.
    j. Endurance.
    k. Short circuit.
    l. Short-time current capability.
    m. Receptacle withstand capability.
    n. Insulating base and supports damage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.

1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

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3. Provide workspace and clearances required by NFPA 70.

B. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.

C. Identify components according to Section 260553 "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

E. Comply with NECA 1.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, motor controls, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Connect twisted pair cable according to Section 260523 "Control-Voltage Electrical Power Cables."

G. Connect twisted pair cable according to Section 271513 "Communications Copper Horizontal Cabling."

H. Route and brace conductors according to manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.

I. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches in length.

3.3 FIELD QUALITY CONTROL

A. Administrant for Tests and Inspections:

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1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. After installing equipment, test for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:

    a. Compare equipment nameplate data with Drawings and Specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, grounding, and required clearances.
    d. Verify that the unit is clean.
    e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
    f. Verify that manual transfer warnings are attached and visible.
    g. Verify tightness of all control connections.
    h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:

        1) Use of low-resistance ohmmeter.
        2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.

    i. Perform manual transfer operation.
    j. Verify positive mechanical interlocking between normal and alternate sources.
    k. Perform visual and mechanical inspection of surge arresters.
    l. Inspect control power transformers.

        1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
        2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
        3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

3. Electrical Tests:

    a. Perform insulation-resistance tests on all control wiring with respect to ground.
    b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
    c. Verify settings and operation of control devices.
    d. Calibrate and set all relays and timers.
    e. Verify phase rotation, phasing, and synchronized operation.
    f. Perform automatic transfer tests.
    g. Verify correct operation and timing of the following functions:

        1) Normal source voltage-sensing and frequency-sensing relays.
        2) Engine start sequence.
        3) Time delay on transfer.

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4) Alternative source voltage-sensing and frequency-sensing relays.
5) Automatic transfer operation.
6) Interlocks and limit switch function.
7) Time delay and retransfer on normal power restoration.
8) Engine cool-down and shutdown feature.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

   a. Check for electrical continuity of circuits and for short circuits.
   b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
   c. Verify that manual transfer warnings are properly placed.
   d. Perform manual transfer operation.

5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.

   a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
   b. Simulate loss of phase-to-ground voltage for each phase of normal source.
   c. Verify time-delay settings.
   d. Verify pickup and dropout voltages by data readout or inspection of control settings.
   e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
   f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
   g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

   a. Verify grounding connections and locations and ratings of sensors.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

E. Transfer switches will be considered defective if they do not pass tests and inspections.

F. Remove and replace malfunctioning units and retest as specified above.

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G. Prepare test and inspection reports.

H. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

D. Video record each training session in accordance with Section 260000 “General Requirements for Electrical.”

END OF SECTION 26 36 00

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SECTION 26 41 13

LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Lightning protection system for ordinary structures.

B. Section Includes: Lightning protection system for the following:

1. Ordinary structures.

1.2 ACTION SUBMITTALS

A. Product Data: For each product.

B. Shop Drawings:

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Include roof attachment details, coordinated with roof installation.
5. Calculations required by NFPA 780 for bonding of metal bodies.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lightning protection cabling attachments to roofing systems and accessories.
2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.

B. Qualification Data: For Installer.

C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

D. Field quality-control reports.

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1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For lightning protection system to include in maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 017839 "Project Record Documents."
b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

B. Completion Certificate:

1. UL Master Label Certificate.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: UL-listed installer, category OWAY or LPI Master Installer.

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION FOR STRUCTURES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Heary Bros. Lightning Protection Co. Inc. (Basis of Design)
2. East Coast Lightning Equipment Inc.
3. Independent Protection Co.

B. Final determination of compliance with these Specifications shall rest with the Engineer, who, at their discretion, may require proof of performance.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.

B. UL Lightning Protection Standard: Comply with UL 96A requirements for Class I buildings.

C. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96 and marked for intended location and application.

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2.3 MATERIALS

A. Air Terminals:

1. Solid, round copper bar.
2. 3/8-inch minimum diameter and shall project 10 inches minimum above the object to be protected.
3. Pointed tip.
4. Integral base support shall be of cast bronze with bolt pressure cable connections and shall be securely mounted with stainless steel screws or bolts. Bases on built-up tar and gravel roofs shall be secured with a proper adhesive and shall have a minimum surface contact area of 18.5 sq. inches. Crimp type connectors are not acceptable.

B. Class I Main Conductors:

1. Stranded Copper: 57,400 circular mils in diameter.

C. Secondary Conductors:

1. Stranded Copper: 26,240 circular mils in diameter.

D. Ground Loop Conductor: Stranded copper.

E. Ground Rods:

1. Material: Solid copper.
2. Diameter: 5/8 inch minimum.
3. Rods shall be not less than 120 inches long.
4. Sectional type, with integral threads.
5. Ground rods shall be connected to the system with a two-bolt cast bronze clamp having a minimum length of 1-1/2 inch and employing stainless steel cap screws.

F. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to [UL 96A] [NFPA 780].

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for [concealed installations in UL 96A] [concealed systems in NFPA 780].

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1. The installation shall be accomplished by an experienced lightning protection systems installer. The installer shall work under the direct supervision of the manufacturer as listed above or a qualified distributor of such manufacturer's products.
2. All equipment shall be installed in a neat workmanlike manner in the most inconspicuous manner possible.
3. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
4. Install conduit where necessary to comply with conductor concealment requirements.
5. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
6. All vertical down lead conductors shall be run concealed on building columns behind finished walls. In addition, all conductors shall be bonded to all metallic objects located within 6 feet of any down lead conductor.
7. On completion of the installation a ground resistance test shall be performed, and a copy of the results shall be furnished to the Architect. Ground resistance shall not exceed 10 Ohms on completion.
8. Aluminum conductors shall not be used below finished grade or run in concrete.
9. The system shall consist of a complete cable network on the roof including all air terminals, splicers and bonds with cable downleads routed concealed either directly in the building construction or in conduit to ground.
10. Downlead cables shall not be brought directly through the roof. Thru-roof connectors with solid rods or conduit through pitch pockets shall be utilized for this purpose.
11. Furnish and install all necessary PVC conduit for concealed down conductors.
12. Copper equipment shall not be connected to aluminum surfaces except by means of bimetal transition fitting. Lead coating shall not to be accepted as a bimetal transition.
13. Locate air terminals in strict accordance with the requirements of NFPA, UL and the system manufacturer. Take care to ensure that all points are within 2'-0" of outside building edge, outside corners, and ridge ends, and that maximum spacing does not exceed 20'-0", and that minimum projection above object protected is 10 inches.
14. Maintain horizontal or downward coursing of main conductor and insure that all bends have at least an 8" radius and do not exceed 90°.
15. Support all exposed roof, downlead, and bonding cables at 3'-0" on center maximum.
16. Ground electrodes shall be installed in strict accordance with the requirements of NFPA, UL and the system manufacturer, but in no instance shall they be less than 1'-0" below grade and 2'-0" from foundation wall. Driven rods shall penetrate earth at least 10'-0".
17. Bond the lightning protection system to the building domestic and fire protection water services and other piping systems in strict accordance with the requirements of NFPA, UL and the system manufacturer.
18. Interconnect lightning protection ground to electric, telephone, and other building ground systems in strict accordance with the requirements of NFPA, UL and the system manufacturer.
19. Bond to metal bodies of conductance on roof with main size conductors in strict accordance with the requirements of NFPA, UL and the system manufacturer. These bonds include but are not limited to exhaust fans, vents, handrails, ladders, metal screens and panels, HVAC units, hatches, skylights, cooling towers, flagpoles, antennas, etc., or any large metal body subject to direct stroke or which exceeds the height of adjacent air terminals.

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20. Bond to metal bodies of inductance located within 6'-0" of main conductor or other bonded objects with approved secondary bonding conductor as shown and as required. Such objects include but are not limited to flashing, metal coping caps, gravel guards, roof drains, downspouts, interior ducts, machinery or piping, etc., or in general any isolated body at or below the roof subject to inductance and within 6'-0" of system.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: bolted connectors.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 COORDINATION

A. The lightning protection installer shall coordinate his work with other trades to ensure a correct, neat, and unobtrusive installation.

B. It shall be the responsibility of the lightning protection installer to assure a sound bond to the main water service and to assure interconnection with other building ground systems, including both telephone and electrical.

3.5 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Perform inspections as required to obtain a UL Master Label for system.

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2. Perform inspections to obtain an LPI certification.

B. Prepare test and inspection reports and certificates.

3.6 COMPLETION

A. The Lightning Protection System installer shall provide the Lightning Protection System as-built drawings and the UL Certification of the system for inclusion in the project Operation and Maintenance Manuals upon completion of the installation.

END OF SECTION 26 41 13

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SECTION 26 43 13

SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type 1 surge protective devices (SPDs).
2. Type 2 surge protective devices (SPDs).
3. Enclosures.
4. Conductors and cables.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 262413 "Switchboards" for integral SPDs installed by switchboard manufacturer.
3. Section 262416 "Panelboards" for integral SPDs installed by panelboard manufacturer.
4. Section 262726 "Wiring Devices" for integral SPDs installed by receptacle manufacturer.

1.2 DEFINITIONS

A. I_n: Nominal discharge current.

B. Maximum Continuous Operating Voltage (MCOV): The maximum designated RMS value of the power frequency voltage that may be continuously applied to the mode of protection of an SPD.

C. Metal-Oxide Varistor (MOV): An electronic component with a significant bidirectional, nonlinear current-voltage characteristic.

D. Mode(s), Modes of Protection, or Protection Modes: Electrical paths where the SPD offers defense against transient overvoltages. Examples include line to neutral (L-N), line to ground (L-G), line to line (L-L), and neutral to ground (N-G).

E. SCCR: Short-circuit current rating.

F. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.

G. Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.

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H. Voltage Protection Rating (VPR): A rating selected from UL 1449 list of preferred values assigned to each mode of protection.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.

a. Include electrical characteristics, specialties, and accessories for SPDs.
b. Certification of compliance with UL 1449 by qualified electrical testing laboratory recognized by authorities having jurisdiction including the following information:

1) Tested values for VPRs.
2) I_n ratings.
3) MCOV, type designations.
4) OCPD requirements.
5) Manufacturer's model number.
6) System voltage.
7) Modes of protection.

B. Field quality-control reports.

1.4 WARRANTY

A. Special Manufacturer Extended Warranty: Manufacturer warrants that SPDs perform in accordance with specified requirements and agrees to provide repair or replacement of SPDs that fail to perform as specified within extended warranty period.

1. Initial Extended Warranty Period: Five (5) years from date of Substantial Completion, for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 TYPE 1 SURGE PROTECTIVE DEVICES (SPDs)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Schneider Electric USA, Inc. (Basis of Design)
2. Eaton.
3. Intermatic, Inc.
4. Leviton Manufacturing Co., Inc.
5. Liebert; Vertiv Holdings Co.
6. Siemens Industry, Inc., Energy Management Division.
7. ABB, Electrification Business.

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B. Source Limitations: Obtain devices from single source from single manufacturer.

C. General Characteristics:

1. Reference Standards: UL 1449, Type 1.
2. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
3. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 200 kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
4. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits must not exceed the following:

    a. Line to Neutral: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
    b. Line to Line: 2000 V for 480Y/277 V and 1200 V for 208Y/120 V.

5. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits must not exceed the following:

    a. Line to Neutral: 700 V.
    b. Line to Line: 1200 V.

6. SCCR: Not less than 200 kA.
7. I_n Rating: 20 kA.

D. Options:

1. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
2. Include indicator light display for protection status.
3. Include audible alarm.
4. Include NEMA ICS 5, dry Form C contacts rated at 2 A and 24 V(ac) for remote monitoring of protection status.
5. Include surge counter.

2.2 TYPE 2 SURGE PROTECTIVE DEVICES (SPDs)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Schneider Electric USA, Inc. (Basis of Design)
2. Eaton.
3. Intermatic, Inc.
4. Leviton Manufacturing Co., Inc.
5. Liebert; Vertiv Holdings Co.
6. Siemens Industry, Inc., Energy Management Division.
7. ABB, Electrification Business.

B. Source Limitations: Obtain devices from single source from single manufacturer.

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C. General Characteristics:

1. Reference Standards: UL 1449, Type 2; UL 1283.
2. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
3. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 100 kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
4. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits must not exceed the following:

    a. Line to Neutral: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
    b. Line to Ground: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
    c. Neutral to Ground: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
    d. Line to Line: 2000 V for 480Y/277 V and 1200 V for 208Y/120 V.

5. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits must not exceed the following:

    a. Line to Neutral: 700 V.
    b. Line to Ground: 700 V.
    c. Neutral to Ground: 700 V.
    d. Line to Line: 1200 V.

6. SCCR: Equal or exceed 200 kA.
7. I_n Rating: 20 kA.

D. Options:

1. Include LED indicator lights for power and protection status.
2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include NEMA ICS 5, dry Form C contacts rated at 2 A and 24 V(ac) for remote monitoring of protection status.
4. Include surge counter.

2.3 ENCLOSURES

A. Indoor Enclosures: Type 1.

2.4 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

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PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's instructions.

B. Install leads between disconnects and SPDs short, straight, twisted, and in accordance with manufacturer's instructions. Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
2. Do not exceed manufacturer's recommended lead length.
3. Do not bond neutral and ground.

C. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.2 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by authorities having jurisdiction.

B. Tests and Inspections:

1. Compare equipment nameplate data for compliance with Drawings and the Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's installation requirements.

C. Nonconforming Work:

1. SPDs that do not pass tests and inspections will be considered defective.
2. Remove and replace defective units and retest.

D. Prepare test and inspection reports.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

3.3 STARTUP SERVICE

A. Complete startup checks in accordance with manufacturer's instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests; reconnect them immediately after the testing is over.

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C. Energize SPDs after power system has been energized, stabilized, and tested.

END OF SECTION 26 43 13

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SECTION 26 50 00

LIGHTING

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, and Section 260000 "General Requirements for Electrical," apply to this Section.

1.3 SUMMARY

A. Section Includes:

1. Interior Lighting
2. Exterior Lighting
3. Classified (Hazardous) Location Lighting.
4. Exit Signs
5. Emergency Lighting
6. Emergency Battery Ballasts & Drivers
7. Luminaire Emergency Transfer Device
8. Poles and Accessories for Support of Luminaires
9. Luminaire Lowering Devices
10. Materials
11. Finishes
12. Luminaire-Mounted Photoelectric Relays.
13. Luminaire Support Components
14. Foundations for Site Lighting Poles and Fixtures

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.4 DEFINITIONS

A. BF: Ballast factor

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B. BUG Rating: Backlight, Uplight and Glare rating. Typically applied to outdoor lighting.

C. CCT: Correlated Color Temperature. The absolute temperature, measured in degrees Kelvin, of a blackbody whose chromaticity most nearly resembles that of the light source.

D. CRI: Color Rendering Index. Measure of the degree of color shift that objects undergo when illuminated by the light source as compared with the color of those same objects when illuminated by a reference source.

E. CU: Coefficient of Utilization. The effective efficiency of a given fixture, in a given space geometry, with given surface reflectance values.

F. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

G. EPA: Equivalent projected area.

H. Fixture: See "Luminaire."

I. IP: International Protection or Ingress Protection Rating.

J. Lamp: The term used to refer to the complete light source package, such as a fluorescent lamp or an LED light engine.

K. LED: Light-emitting diode.

L. LER: Luminaire efficacy rating.

M. Lumen: Measured output of lamp and luminaire, or both.

N. Luminaire: Complete lighting fixture, including lamp/light source; lamp sockets or mounting equipment; housing; ballast/driver (if required); diffusers/refractors or light control medium; and other appurtenances required for a complete, fully functional installation.

O. MacAdam Ellipse: A region on a chromaticity diagram which contains all colors which are indistinguishable, to the average human eye, from the color at the center of the ellipse.

P. Pole: Luminaire-supporting structure, including towers used for large-area illumination.

Q. RCR: Room cavity ratio. A single numerical value summarizing the complete space geometry including length, width, and height.

R. SSL: Solid State Lighting, which refers to a type of lighting that uses semiconductor light-emitting diodes (LEDs), organic light-emitting diodes (OLED), or polymer light-emitting diodes (PLED) as sources of illumination rather than electrical filaments, plasma (used in arc lamps such as fluorescent lamps), or gas.

S. Standard: See "Pole."

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1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.

6. Printed photometric data and adjustment factors based on laboratory tests including photometric data which includes luminaire efficiency and Coefficient of Utilization table for the specific luminaire configuration specified, complying with IES "Lighting Measurements Testing and Calculation Guides" for each luminaire type. Photometric data shall be provided in printed form. Inclusion of the .ies file only is not acceptable.

   a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings – Building Interior: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
4. Structural members to which equipment and/or luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:

   a. Other luminaires.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Ceiling-mounted projectors.

7. Moldings or other architectural features.

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B. Coordination Drawings – Site Lighting: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Structural members to which equipment and luminaires will be attached.
3. Underground utilities and structures.
4. Existing underground utilities and structures.
5. Above-grade utilities and structures.
6. Existing above-grade utilities and structures.
7. Building features.
8. Vertical and horizontal information.

C. Material Test Reports:

1. For each foundation component, by a qualified testing agency.
2. For each pole, by a qualified testing agency.

D. Sample Warranty: Manufacturer's standard warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1.8 SUBSTITUTIONS

A. The lighting design is based on the fixture type and manufacturers specified and only the fixture indicated by catalog number has been approved. Should a substitute fixture be proposed for one or more of those specified, the Design Professional may request a working sample of one or more of the proposed substitutions, as well as a sample of the comparable fixture to allow side by side comparison. Where substitutions are requested, they shall be provided promptly to the Design Professional's office, along with complete photometric data, prepared and certified by an independent lighting fixture testing laboratory for both the specified and proposed substitute fixtures. Fixture samples shall be full working samples, complete with lamps, cord & NEMA 5-15P plug, 120 volt ballast or driver and any controls required to demonstrate the full luminaire operating performance.

B. The substituted fixture(s) shall be equal or better in quality to that specified and will be evaluated by the Design Professional based on the following comparisons:

1. Appearance
2. Performance:

    a. Light Distribution (independent testing laboratory certified photometrics, etc.)
    b. Luminaire Efficiency Rating
    c. Coefficient of Utilization
    d. Spacing to Mounting Height Ratio (parallel and perpendicular)

3. Construction

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a. Similar materials
b. Quality and Gauge of Materials
c. Finishes
d. Workmanship
e. Rigidity
f. Installation Ease

4. Maintainability:

a. Hinging and Latching
b. Cleaning and Relamping
c. Ballast/Driver replacement

C. Whenever Solid State Lighting (SSL) type fixtures are proposed to be substituted for those specified, and for any other fixture substitutions as requested by the Design Professional during the review process, provide point by point lighting calculations for each room or area to allow more specific review of the actual fixture performance in actual project situations. Point by point calculations shall be provided for both the specified and proposed substitute light fixtures, with illumination at points on a 1' x 1' grid for interior spaces and a 5' x 5' grid for exterior areas. Point by point calculations shall provide performance summaries for each area to be illuminated. The calculation boundaries shall be set to calculate only the actual area to be illuminated, with adjacent areas not included in the calculations or performance summaries. The performance summary shall include the following data:

1. Average illumination (footcandles)
2. Minimum illumination (footcandles)
3. Maximum illumination (footcandles)
4. Maximum to minimum illumination ratio
5. Average to minimum illumination ratio
6. Total lighting system input watts
7. Light Loss Factor (LLF) used
8. Fixture Coefficient of Utilization (C.U.)

1.9 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications:

1. Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Each LED luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.10 DELIVERY, STORAGE, AND HANDLING – SITE LIGHTING POLES

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

B. Package aluminum poles for shipping according to ASTM B660.

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C. Store poles on decay-resistant skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

1.11 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires which fail in materials or workmanship within the project warranty period specified in Section 260000 and Division 1 sections.

B. Special Warranties. Manufacturer and Installer agree to repair or replace the following components which fail in materials or workmanship within the periods specified below:

1. Special Extended Warranty for Ballasts and Drivers:

a. Manufacturer's standard form in which ballast/driver manufacturer agrees to repair or replace ballasts or drivers which fail in materials or workmanship within specified warranty period:

1) Special Warranty Period for LED Drivers: Five (5) years from date of project Substantial Completion.

2. Special Warranty for Exterior Luminaires and Poles:

a. Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1) Warranty Period for Luminaires, Poles, and accessories: Repair or replace exterior luminaires, poles and standards and accessories that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than five (5) years from date of project Substantial Completion.

3. Special Extended Warranty on Luminaire Emergency Transfer Devices:

a. Manufacturer's standard form in which Luminaire Emergency Transfer Device manufacturer agrees to repair or replace devices which fail in materials or workmanship within five (5) years from date of project Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Refer to Lighting Fixture Schedule on the drawings for complete list of luminaire types, descriptions, lamping, and manufacturers.

B. Provide luminaires from a single manufacturer for each luminaire type.

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2.2 LUMINAIRE REQUIREMENTS:

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, "National Electrical Code," by a qualified testing agency, and marked for intended location and application.

B. Factory-Applied Labels: Comply with UL 1598, "Luminaires." Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI.

C. Recessed luminaires shall comply with NEMA LE 4, "Recessed Luminaires, Ceiling Compatibility."

1. Where lighting fixtures are indicated to be recessed mounted, coordinate with the actual ceiling type into which the fixture is to be installed. Furnish and install all required mounting accessories, installation kits, fixture modifications etc. as may be required to install the fixture in the ceiling type as indicated on the Architectural Reflected Ceiling Plan. Exact ceiling finishes and types shall be coordinated with the Architectural Drawings. The indication of a ceiling grid system on the electrical drawings shall not relieve the Contractor of their obligation to verify ceiling construction.
2. Where recessed lighting fixtures are to be mounted in a fire rated ceiling, a fire protective enclosure shall be provided around the fixture assembly in order to maintain the fire rated integrity of the ceiling. The fire rated enclosure shall be provided under the Electrical Divisions and shall be installed by a qualified Acoustical Ceiling Contractor. The fire rated enclosure shall be installed in full accordance with all manufacturers recommendations. Fixtures provided with such protection shall be UL listed for installation in contact with insulating materials and shall be provided with suitable thermal protection. Coordinate with the Architectural drawings to determine where, if any, such protection may be required. Fixtures which are UL listed as being of the same fire resistive rating as the ceiling will not be required to have such enclosures, provided that the UL listing is certified and included with the Lighting Fixture Submittals.

D. UL Compliance: Comply with UL 1598, "Luminaires."

E. Lamp base complying with ANSI C81.61, "American National Standard for Electrical Lamp Bases."

F. Except as specifically indicated otherwise, luminaires utilizing ballasts or drivers shall have auto-sensing ballast/driver suitable for use on Nominal Operating Voltage from 120 through 277 volts.

2.3 PERFORMANCE REQUIREMENTS – EXTERIOR LIGHTING:

A. Site Lighting Poles:

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1. Structural Characteristics: Comply with AASHTO LTS-6-M, "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals."
2. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied according to AASHTO LTS-6-M.
3. Live Load: Single load of 500 lbf distributed according to AASHTO LTS-6-M.
4. Ice Load: Load of 3 lbf/sq. ft., applied according to AASHTO LTS-6-M for applicable areas on the Ice Load Map.

B. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.

1. Basic wind speed for calculating wind load for poles 50 feet high or less is 90 mph.

a. Wind Importance Factor: 1.0.
b. Minimum Design Life: 25 years.
c. Velocity Conversion Factor: 1.0.

C. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.

D. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.4 LED REPLACEMENT LAMPS:

A. Provide integral driver LED lamps for luminaires which are provided with standard lamp sockets, or for relamping of all existing fixtures indicated to remain.

B. LED Lamps shall match shape, size, appearance, beam spread, voltage and lumen rating of the lamp on which the luminaire is based. Lamp base shall exactly match that of the luminaire into which it is to be installed.

C. Unless a higher rating is indicated in the Lighting Fixture Schedule, the LED lamps shall have a minimum Color Rendering Index (CRI) of 80. Lamp shall be of the Correlated Color Temperature (CCT) indicated in the Lighting Fixture Schedule.

D. All LED lamps shall be suitable for dimming down to a minimum of 10% full light output.

E. LED Lamps for indoor or protected outdoor use shall be UL listed as suitable for damp locations. Lamps for outdoor, or for high humidity indoor spaces, shall be UL listed as suitable for wet locations. All LED lamps shall be Energy Start Certified.

F. Provide a complete list of all LED Replacement Lamps to be utilized for the project, along with manufacturer data sheet for each lamp type.

2.5 DRIVERS:

A. General:

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1. Provide proper drivers for all fixtures employing lamps which require ballasts, drivers, transformers, or other lamp power supply devices.
2. LED drivers and fluorescent ballasts shall operate from a 120 through 277 volt (auto selecting), 60 hertz input source with sustained variations of +/- 10% (voltage and frequency) with no damage to the driver or ballast.
3. All ballasts and drivers shall be UL component recognized.
4. All ballasts and drivers shall be certified Polychlorinated Biphenyl (PCB) free.
5. Electronic drivers, where specified hereinafter, shall meet the requirements of the Federal Communications Commission rules and regulations, Title 47 CFR part 18, for Non-Consumer equipment.

B. Light Emitting Diode (LED) Drivers:

1. Light Emitting Diode (LED) Driver shall be mounted in an all metal housing suitable for use in air handling plenums.
2. LED driver output shall be regulated to +/- 5% across published load range.
3. LED driver shall operate LED's at their rated input voltage of 12 volts, 24 volts or DC where Luxeon LED's are provided.
4. LED driver shall have a Power Factor greater than 0.90 for primary application.
5. LED Driver input current shall have Total Harmonic Distortion (THD) of less than 20%.
6. LED Driver shall have a Class A sound rating.
7. LED Driver shall have a minimum operating temperature of -40C (-40F).
8. LED Driver shall tolerate sustained open circuit and short circuit output conditions without damage and without need for external fuses or trip devices.
9. LED driver shall not contain any Polychlorinated Biphenyl (PCB).
10. LED driver shall be Underwriters Laboratories (UL) listed, Class 2 Outdoor.
11. LED driver shall comply with ANSI C62.41 Category A for Transient protection.
12. LED driver shall comply with the requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 15, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).
13. LED drivers shall be warrantied for a period of five-years from date of project substantial completion against defects in material or workmanship, including replacement, for operation at a maximum case temperature of 90C.
14. LED driver shall be Philips Advance Transformer Xitanium™ or approved equal.
15. Dimming:

    a. All LED drivers shall provide for dimming, at a minimum from 10% to 100% of light output, unless a wider dimming range is specified in the Lighting Fixture Schedule. Unless otherwise indicated, dimming protocol shall be 0-10 VDC. Coordinate specific dimming protocol requirements with Automated Lighting Controls.
    b. Provide a complete system of fixtures, LED's, electronic dimming LED drivers and dimming controls which are certified by the manufacturers of each component for use together as a complete, fully functional system.

2.6 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING:

A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, "National Electrical Code" and UL 924, "Standard for Emergency Lighting and Power Equipment" by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

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B. Comply with NFPA 101, "Life Safety Code."

C. Comply with NEMA LE 4, "Recessed Luminaires, Ceiling Compatibility" for recessed luminaires.

D. Comply with UL 1598, "Luminaires."

2.7 EMERGENCY BATTERY UNITS:

A. Provide self-contained Emergency Battery Units to provide emergency lighting in case of utility power failure and/or generator failure in the main electric room or where indicated on the drawings.

B. Battery shall be sealed, maintenance-free, lead-acid type.

C. Battery charger shall be fully automatic, solid-state type with sealed transfer relay.

D. Light source shall be white LED.

E. Operation: The transfer relay shall automatically turn lamps on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Battery shall provide operation of integral lamps, plus any attached remote heads, for a minimum of 90 minutes. Lamps shall be automatically disconnected from battery when voltage approaches deep-discharge level. When normal power supply circuit voltage is restored, the relay shall automatically disconnect the lamps from battery, and the battery shall be automatically recharged. The battery shall be maintained at full charge by automatic float charge operation.

F. Provide a Push-To-Test switch, in unit housing, which shall simulate the loss of normal power and demonstrate unit operability.

G. Provide an LED Indicator Light to indicate normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

H. Integral Self-Test:

1. Emergency Battery Units shall include an Integral Self-Test feature which shall automatically initiate a code-required test of unit emergency operation at required intervals. Failure of the unit shall be annunciated by an integral audible alarm and flashing red LED.

2.8 EXIT SIGNS:

A. General Characteristics: Comply with UL 924, "Standard for Emergency Lighting and Power Equipment;" for sign colors, visibility, luminance, and lettering size, comply with local Authorities Having Jurisdiction requirements.

B. Provide exit signs as indicated on the drawings, to indicate exit/egress pathways throughout the building. Exit signs shall comply with UL Standard 924, "Standard for Emergency Lighting and Power Equipment," with NFPA-101, "Life Safety Code," and with requirements of the local

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Authority Having Jurisdiction (AHJ) for sign colors, visibility, luminance, and lettering size. Confirm color of exit sign with local Authority Having Jurisdiction prior to ordering of exit signs.

C. Exit signs shall bear the United States Environmental Protection Agency (EPA) Energy Star Label.

D. Lamps shall be LEDs with 70,000 hours minimum rated lamp life.

2.9 LED EMERGENCY BATTERY DRIVER UNITS:

A. Where indicated in the Lighting Fixture Schedule on the drawings, provide LED Emergency Battery Driver Units to serve LED lighting fixtures for emergency lighting purposes. The fixture to which the LED Emergency Battery Driver Unit shall operate at 100% output when operating on battery power for a minimum of 90 minutes.

B. Provide self-contained, modular, battery-inverter unit. Units for LED fixtures shall be external type, remote mounted from lighting fixture, in an enclosure UL listed for installation in air handling plenum spaces.

C. Comply with UL Standard 924, "Standard for Emergency Lighting and Power Equipment."

D. Emergency Connection: The LED Emergency Battery Driver Unit shall operate the entire fixture at its normal rated lumen output. Connect unswitched circuit to LED Emergency Battery Driver Unit and switched circuit to fixture driver.

E. The LED Emergency Battery Driver Unit shall include a remote Test Push Button and Indicator Light which shall be visible and accessible without opening fixture or entering ceiling space.

1. Push Button shall be push-to-test type, mounted in the ceiling adjacent to the fixture. The Test Push Button shall simulate loss of normal power and demonstrate unit operability.
2. Indicator Light shall be an LED which indicates normal power on. Normal glow shall indicate trickle charge; bright glow shall indicate charging at end of discharge cycle.

F. Battery shall be sealed, high temperature, maintenance-free, nickel-cadmium type.

G. Charger shall be fully automatic, solid-state, constant-current type with sealed power transfer relay.

H. LED Emergency Battery Driver Units shall be Philips Bodine series BSL, which shall form the basis of design. Subject to compliance with all contract requirements, substitutions may be considered from Dual-Lite, Iota or Lithonia.

2.10 LUMINAIRE EMERGENCY TRANSFER DEVICE (LETD):

A. Provide a Luminaire Emergency Transfer Device unit at each fixture indicated for emergency power operation. It shall be mounted either within the fixture ballast channel, as for troffer style fixtures, or exposed in accessible ceiling space adjacent to the fixture for downlights, wall sconces and similar fixtures. The unit housing shall be steel, NEMA 1 rated for dry or damp locations, and UL listed as suitable for installation in air handling plenum spaces.

NOT FOR BIDDING PURPOSES

B. The Luminaire Emergency Transfer Device shall either bypass the lighting control, or where 0-10 volt control is provided, shall automatically drive the control to provide 100% light output when operating on emergency power.

C. The unit shall be listed by Underwriters Laboratories in accordance with standard UL 924, "Emergency

D. Lighting and Power Equipment." It shall be listed for factory or field installation.

E. The Luminaire Emergency Transfer Device shall be fully warranted, against defects in materials and workmanship, for a period of five (5) years from the date of project Substantial Completion.

F. Luminaire Emergency Transfer Device shall be Philips Bodine GTD10DIM, which shall form the Basis of Design. Subject to compliance with all contract requirements, substitutions may be considered from Dual-Lite or the fixture manufacturer.

2.11 ALUMINUM POLES:

A. Poles: Seamless, extruded structural tube complying with ASTM B221, Alloy 6063-T6, with access handhole in pole wall.

1. Shape: Square, straight.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

B. Mast Arms: Aluminum type, continuously welded to pole attachment plate. Material and finish same as plate.

C. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with [stainless] [galvanized]-steel bolts.
2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

E. Grounding and Bonding Lugs: Bolted 1/2-inch threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

F. Fasteners: Galvanized steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as to substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

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G. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.

H. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I clear coating of 0.018 mm or thicker), complying with AAMA 611.

I. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

    a. Color: As selected by Architect from manufacturer's full range.

J. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Powder coat shall comply with AAMA 2604.

    a. Electrostatic applied powder coating; single application with a minimum 2.5- to 3.5-mils dry film thickness; cured according to manufacturer's instructions. Coat interior and exterior of pole for equal corrosion protection.
    b. Color: As selected by Architect from manufacturer's full range.

2.12 MOUNTING HARDWARE:

A. Anchor Bolts: Manufactured with a minimum yield strength of 55,000 psi.

1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.
2. Bent rods minimum 3/4 inches diameter by minimum 24 inches in length, unless larger recommended by pole manufacturer.

NOT FOR BIDDING PURPOSES

3. Threading: Uniform National Coarse.

B. Nuts: ASTM A563, Grade A, Heavy-Hex.

1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.
2. Two nuts provided per anchor bolt, shipped with nuts pre-assembled to the anchor bolts.

C. Washers: ASTM F436, Type 1.

1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.
2. Two washer(s) provided per anchor bolt.

2.13 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for sheet steel.

C. Stainless Steel:

1. Manufacturer's standard grade.

D. Galvanized Steel: ASTM A653/A653M.

E. Aluminum: ASTM B209.

F. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

G. Lenses, Diffusers, and Globes:

1. Glass: Clear glass shall be annealed crystal glass unless otherwise indicated.
2. Fresnel Glass: Tempered
3. Acrylic Lighting Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
4. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

H. Factory-Applied Labels: For luminaires with field replaceable lamps, comply with UL 1598, “Luminaires.” Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

NOT FOR BIDDING PURPOSES

1. Label shall include the following lamp characteristics:

    a. "USE ONLY" and include specific lamp type.
    b. Lamp diameter, shape, size, wattage, and coating.
    c. CCT and CRI for all luminaires.

2.14 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.15 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.16 FINISHES – EXTERIOR LIGHTING

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping.

1. Where indicated, match finish process and color of pole or support materials.
2. Where indicated, provide custom color based on sample provided or Based on manufacturer color number.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with National Association of Architectural Metal Manufacturers (NAAMM) "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish shall be as indicated in the Lighting Fixture Schedule on the drawings, as follows:

    a. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
    b. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
    c. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

NOT FOR BIDDING PURPOSES

d. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.
e. Color: As indicated in the Lighting Fixture Schedule.

D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As indicated in the Lighting Fixture Schedule.

2.17 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773, “Standard for Plug-In Locking Type Photocontrols for Use with Area Lighting.”

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with ANSI C136.10.
2. Adjustable window slide for adjusting on-off set points.

2.18 LUMINAIRE SUPPORT COMPONENTS:

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Wires for Humid Spaces: ASTM A580/A580M, Composition 302 or 304, annealed stainless steel, 12 gage.

E. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

F. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

NOT FOR BIDDING PURPOSES

2.19 POWER-INSTALLED SCREW FOUNDATIONS FOR SITE LIGHTING POLES AND FIXTURES:

A. At the Contractor's Option, foundations for pole mounted luminaires may be Power Installed Screw Foundations.

B. Power Installed Screw Foundations shall be a factory fabricated assembly, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

C. Baseplate: Stamped with manufacturer's name, date of production, and cable entry.

D. Submit data to indicate applicability of pole foundation to poles intended for project.

E. Power installed screw foundations shall be self augering steel bases as manufactured by A.B. Chance, a Division of Hubbell Power Systems, Inc., or approved equal. Install foundations in strict accordance with all manufacturers recommendations.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, roofs, canopies and overhangs for suitable conditions where luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING:

A. If approved by the Design Professional, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting.

3.3 INSTALLATION:

A. Comply with NECA 1, Standard for Good Workmanship In Electrical Construction.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps/light source in each luminaire, as recommended by the luminaire manufacturer.

D. Supports:

NOT FOR BIDDING PURPOSES

1. In no case shall the weight of the luminaire or any component thereof be supported by ceiling tiles.
2. Sized and rated for luminaire and all associated components weight.
3. Able to maintain luminaire position after cleaning and relamping.
4. Provide support for luminaire without causing deflection of ceiling or wall.
5. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Luminaires Mounted in Suspended Grid Type Ceilings:

1. Secure to any required outlet box.
2. Secure luminaire to the ceiling grid using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components (ceiling hanger wires, etc.) to connect ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.
4. 1x4, 2x2, 2x4, and linear recessed luminaires shall be supported independent of the ceiling grid.

F. Flush-Mounted Luminaires:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

G. Wall-Mounted Luminaires:

1. Attached to structural members where located in appropriate position, or to a minimum 20 gauge backing plate attached to wall structural members where wall structural members are not located where needed.
2. Do not attach luminaires directly to gypsum board.

H. Suspended Luminaires:

1. Ceiling Mount, by one of the following methods as indicated in the Lighting Fixture Schedule:

   a. Minimum of two 5/32-inch diameter aircraft cable supports, adjustable in length.
   b. Pendant mount, with field adjustable pendant tubes or rods.
   c. Hook mount.

2. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
3. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing, rod or aircraft cable support for suspension for each unit length of luminaire chassis, including one at each end.

NOT FOR BIDDING PURPOSES

5. Do not use ceiling grid as support for suspended luminaires. Connect support wires or rods to building structure.

I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 INSTALLATION – EXTERIOR LUMINAIRES:

A. Wiring Method: Install cables in raceways. Conceal raceways and cables.

B. Install luminaires level, plumb, and square with finished grade unless otherwise indicated.

C. Install floodlight type luminaires at height and aiming angle as indicated on drawings.

D. Coordinate layout and installation of luminaires with other construction.

E. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

F. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533.13 Conduits for Electrical Systems" and 260533.16 "Boxes and Covers for Electrical Systems" for wiring connections and wiring methods.

3.5 INSTALLATION OF BOLLARD LUMINAIRES:

A. Align units for optimum directional alignment of light distribution.

1. Install on concrete base with top 4 inches above finished grade or flush with adjacent paved surface at luminaire location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth.

3.6 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES:

A. Aim as indicated on Drawings.

B. Install on concrete base with top 4 inches above finished grade or flush with adjacent paved surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.7 POLE FOUNDATIONS:

A. Cast-in-Place Concrete Pole Foundations:

1. Provide cast in place reinforced concrete foundations for all site lighting poles, bollards, floodlights and other fixtures which are not mounted on buildings or other structural elements.

NOT FOR BIDDING PURPOSES

2. Anchor Bolts: Provide anchor bolts to match pole-base flange. Install plumb using manufacturer-supplied template, uniformly spaced.
3. Concrete foundations shall extend a minimum of 1/6 of the pole height below grade, but in no case shall the bottom of the excavation be less than 4 feet below grade.
4. Foundations for poles within 5 feet of driveways, parking lots, and other traffic areas shall extend a minimum of 24" above finished grade. Foundations for other poles and fixtures shall be set flush with grade unless otherwise noted.
5. For poles taller than 25', or for poles taller than 10' in sandy or unstable soil, engage the services of a Registered Professional Structural Engineer to design the pole foundation. Submit drawing, signed and sealed by the Structural Engineer, for concrete foundation design prior to beginning installation.
6. Provide ¾" diameter x 10'-0" long copper clad steel ground rod at each site lighting pole. Bond ground rod to pole grounding lug and to circuit ground conductors within pole. Connection to ground rod shall be via exothermic weld connection.
7. Once concrete has set, remove all above grade formwork. Rub exposed portions of base smooth and parge with skim coat of finish concrete.

B. Pre-Cast Foundations:

1. Factory fabricated, with structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories.

C. Power-Installed Screw Foundations:

1. Foundations for poles shall be set flush with grade unless otherwise noted or specified below.
2. Foundations for poles within 5 feet of driveways, parking lots, and other traffic areas, or where indicated on the drawings to be a raised foundation, shall extend a minimum of 24" above finished grade. Halt penetration of the foundation at the proper depth to achieve the base height desired. After feeding the power conduit through the cableway and out the baseplate, install a tube-type form and encase the exposed section of the power installed screw foundation shaft in poured-concrete from a minimum of 24" below grade to the height noted above grade.

3.8 POLE INSTALLATION:

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.

1. Fire Hydrants and Water Piping: 60 inches.
2. Water, Gas, Electric, Communications, and Sewer Lines: 5 feet.
3. Trees: 15 feet from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer.

NOT FOR BIDDING PURPOSES

D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.

1. Grout void between pole base and foundation. Use non-shrink or expanding concrete grout firmly packed to fill space.
2. Install base covers unless otherwise indicated.
3. Use a short piece of 1/2 -inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

3.9 GROUNDING:

A. Ground Metal Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground Nonmetallic Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundation.

3.10 CORROSION PREVENTION:

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.

B. Steel Conduits: Comply with requirements in Section 260533.13 "Conduits for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

3.11 IDENTIFICATION:

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.12 FIELD QUALITY CONTROL:

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

NOT FOR BIDDING PURPOSES

2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Illumination Tests – Exterior Lighting:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

a. IES LM-64, "Photometric Measurements Of Parking Areas."
b. IES LM-72, "Directional Positioning Of Photometric Data."

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

C. Luminaire will be considered defective if it does not pass operation tests and inspections.

D. Prepare test and inspection reports.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

F. Tests and Inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

G. Nonconforming Work:

1. Luminaire will be considered defective if it does not pass operation tests and inspections.
2. Remove and replace defective units and retest.

H. Prepare Test and Inspection Reports.

I. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections as required.

3.13 ADJUSTING:

A. Aiming: Where Luminaires include adjustable or aimable light output, adjust or aim the fixtures to provide the best illumination, and to illuminate the intended subject.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.

NOT FOR BIDDING PURPOSES

2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Design Professional.

C. Emergency Lighting Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect luminaires. Replace lamps, emergency power units, batteries, exit signs, and luminaires that are defective.

a. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

2. Conduct short-duration tests on all emergency lighting.

3.14 SYSTEM STARTUP:

A. Perform startup service:

1. Charge emergency power units and batteries minimum of one hour and depress switch to conduct short-duration test.
2. Charge emergency power units and[batteries minimum of 24 hours and conduct one-hour discharge test.

3.15 DEMONSTRATION

A. Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

3.16 PROTECTION

A. Remove and replace luminaires and exit signs that are damaged or caused to be unfit for use by construction activities.

3.17 RELAMPING PROVISIONS:

A. Instruct Owners Representative in proper manner of maintaining and relamping all lighting fixtures.

B. Provide facilities for relamping of fixtures by the Owner’s maintenance personnel. Provide two (2) of all tools or accessories required for fixture access.

3.18 LUMINAIRE AIMING SESSION:

A. Following completion of the lighting installation, including all controls, dimming systems, etc., provide a Luminaire Aiming Session in conjunction with the Owner Engineer, and Architect. This session shall be of sufficient duration to accurately aim all adjustable lighting fixtures within the project area. The aiming session shall be conducted at dusk or later to avoid impact from natural lighting sources.

NOT FOR BIDDING PURPOSES

B. Each adjustable lighting fixture shall be individually adjusted to best illuminate the intended area or feature, to the complete satisfaction of the Owner and the Design Professional. Once a fixture has been aimed, it shall be securely locked in that position using locking mechanisms built into the fixture. Mark, with permanent markers on the fixture housing, exact aiming positions to permit fixture to be returned to the identical position following future re-lamping or maintenance.

C. Provide all required labor, materials, lifts, ladders, equipment, etc. as required to perform the fixture aiming. Provide a properly calibrated digital light meter for taking illumination readings. Provide two-way radio system for communications during the aiming session. Have sufficient stock of spare lamps of each type used in the project on hand to replace burned out or damaged lamps.

END OF SECTION 26 50 00

NOT FOR BIDDING PURPOSES

SECTION 26 52 13

EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 SUMMARY

A. Section Includes:

1. Emergency lighting.
2. Exit signs.
3. Materials.
4. Luminaire support components.

B. Related Requirements:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, and Section 260000 "General Requirements for Electrical," apply to this Section.

1.3 DEFINITIONS

A. Correlated Color Temperature (CCT): The absolute temperature, measured in kelvins, of a blackbody whose chromaticity most nearly resembles that of the light source.

B. Color Rendering Index (CRI): Measure of the degree of color shift that objects undergo when illuminated by the light source as compared with the color of those same objects when illuminated by a reference source.

C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Lumen (lm): The SI derived unit of luminous flux equal to the luminous flux emitted within a unit solid angle by a unit point source (1 lm = 1 cd-sr).

1.4 ACTION SUBMITTALS

A. Product Data:

1. For each type of emergency lighting unit, exit sign, and emergency lighting support.

NOT FOR BIDDING PURPOSES

a. Include data on features, accessories, and finishes.
b. Include physical description of unit and dimensions.
c. Battery and charger for light units.
d. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
e. Include photometric data and adjustment factors based on laboratory tests by, or under supervision of, qualified luminaire photometric testing laboratory, for each luminaire type.

B. Shop Drawings:

1. For nonstandard or custom luminaires.

a. Include plans, elevations, sections, and mounting and attachment details.
b. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
c. Include diagrams for power, signal, and control wiring.

C. Product Schedule:

1. For emergency lighting units.
2. For exit signs.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of luminaire.

B. Product Test Reports: For each luminaire for tests performed by, or under supervision of, qualified luminaire photometric testing laboratory.

1.6 QUALITY ASSURANCE

A. FM Global Compliance: Luminaires for hazardous locations must be listed and labeled for indicated class and division of hazard by FM Global.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

NOT FOR BIDDING PURPOSES

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70 and UL 924, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

B. Comply with NFPA 101.

C. Comply with NEMA LE 4 for recessed luminaires.

D. Comply with UL 1598 for fluorescent luminaires.

2.2 EMERGENCY LIGHTING

A. General Characteristics: Self-contained units.

B. Emergency Luminaire:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Cooper Lighting Solutions; Signify North America Corp.
b. Lithonia Lighting; Acuity Brands Lighting, Inc.
c. Philips; Signify North America; Signify Holding.

2. Options:

a. Operating at nominal voltage of 277 V(ac).
b. Internal emergency power unit.
c. Rated for installation in damp locations, and for sealed and gasketed luminaires in wet locations.
d. UL 94 flame rating.

2.3 EXIT SIGNS

A. General Characteristics: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Sign:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Cooper Lighting Solutions; Signify North America Corp.
b. Lithonia Lighting; Acuity Brands Lighting, Inc.
c. Philips; Signify North America; Signify Holding.

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2. Options:

a. Operating at nominal voltage of 277 V(ac).
b. Lamps for AC Operation:

1) LEDs; 50,000 hours minimum rated lamp life.

c. Master/Remote Sign Configurations:

1) Master Unit: Comply with requirements above for self-powered exit signs and provide additional capacity in LED power supply for power connection to remote unit.
2) Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

2.4 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 0.106 inch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

B. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position when testing emergency power unit.

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3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices must be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

C. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

D. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inch, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

E. Ceiling Grid Mounted Luminaires:

1. Secure to outlet box, if provided.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by authorities having jurisdiction.

B. Tests and Inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

C. Nonconforming Work:

1. Luminaire will be considered defective if it does not pass operation tests and inspections.
2. Remove and replace defective units and retest.

D. Prepare test and inspection reports.

E. Manufacturer Services:

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1. Engage factory-authorized service representative to support field tests and inspections as required.

3.5 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect luminaires. Replace exit signs and luminaires that are defective.

a. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

2. Conduct short-duration tests on all emergency lighting.

3.6 PROTECTION

A. Remove and replace luminaires and exit signs that are damaged or caused to be unfit for use by construction activities.

END OF SECTION 26 52 13

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SECTION 27 00 00

GENERAL REQUIREMENTS FOR TELECOMMUNICATIONS

PART 1 - GENERAL

1.1 STIPULATIONS:

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

B. This Section shall apply to all Divisions 26, 27, and 28 Sections of these specifications as hereinafter written.

C. Instructions to Bidders, Bidding Forms, Forms of Agreement between Owner and Contractor, Contract Award Date, Starting and Completion Dates, Conditions of the Contract, Insurance Requirements, and other Owner Requirements will be furnished separately by the Owner. These documents, as well as any addenda issued, shall form a part of these Specifications, and this contractor shall consult them in detail for instructions pertaining to this work.

D. Each trade contractor shall receive all drawings and specification sections issued as part of the overall bid package. All contractors are to receive, review, and coordinate all of their work as shown or referenced on the other trade documents. All work shown or referenced on the other trade documents shall be included as part of the overall project scope for that particular discipline and trade.

1.2 SCOPE OF WORK:

A. These specifications and accompanying drawings are intended to cover the furnishing of all labor, material, and equipment and superintendence of the Telecommunications System.

B. It is the intent and purpose of these specifications and accompanying drawings to cover and include each item, all materials, machinery, apparatus, and labor necessary to properly install, equip, adjust, and put into perfect operation the respective portions of the installations specified and to so interconnect the various items or sections of the work as to form a complete and properly operating whole.

C. Any equipment, apparatus, machinery, material, and small items not mentioned in detail, and labor not hereinafter specifically mentioned, which may be found necessary to complete or perfect any portion of installation in a substantial manner, and in compliance with the requirements stated, implied, or intended in these specifications shall be furnished without extra cost. This shall include all materials, devices, or methods peculiar to the machinery, equipment, apparatus, or systems furnished and installed as part of the Telecommunications work.

D. The term "Furnish" shall mean to obtain and supply to the job site. The term "Install" shall generally mean to fix in position and connect for use. Where language indicates that one party or trade is to "install", and another is to "connect", the term "install" shall mean only to fix in

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position, and "connect" shall mean to make electrical connections to. The term "Provide" shall mean to furnish and install.

1.3 LAWS, REGULATIONS AND CODES:

A. Perform all work in strict compliance with all laws, regulations, and/or codes applying, including all Federal, State and local codes and any other authority having jurisdiction. Wherever drawings or specifications conflict with such regulations they shall be made to conform, and approval of the Design Professional obtained on such changes as may be involved.

B. All electrical and telecommunications work shall comply with the requirements of the National Electrical Code, latest revision.

1.4 PERMITS, FEES, AND CERTIFICATES OF APPROVAL:

A. Unless stated otherwise in General Conditions or Division 1, obtain and pay for all permits, fees, and licenses required, including those of utilities and Agencies. Provide copies to Design Professional in the quantity requested. "Fees" shall include connection charges construction costs, and other such charges by utility companies or service providers. Ascertain such charges during bidding period and include bid price.

B. As a prerequisite to final acceptance, supply to the Design Professional a Certificate of Inspection from an Electrical Inspection Agency acceptable to the Owner and approved by the local municipality and the utility company serving the project. Certificate shall cover rough wiring, fixtures, and equipment.

1.5 RECORD DRAWINGS:

A. During construction keep an accurate record of all deviations of the work as shown on the drawings and that which is actually installed.

B. Secure from the Design Professional, a complete set of prints of the Telecommunications drawings and note changes thereon. Make a complete record in a neat and accurate manner, of all changes and revisions to original design which exist in completed work, in CAD file format.

C. The cost of furnishing above CADD files and preparing these record drawings shall be borne by the contractor. When all revisions showing the work as finally installed are made, the corrected prints and CADD files shall be submitted for review and approval by the Design Professional.

D. Record drawings shall be delivered to Owner within 30 days after acceptance of completed project by Owner.

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1.6 OPERATING INSTRUCTIONS:

A. Provide to the Owner three bound copies of complete written instruction on the operation, care and maintenance of each piece of equipment and the installation as a whole. Include frequency of inspection, cleaning and adjusting and other attention as may be required in accordance with manufacturer's instructions. Material shall be manufacturer's brochures, catalog cuts, parts lists, wiring diagrams, etc. Also supply Owner with three complete sets of approved shop drawings.

B. Furnish qualified personnel to instruct the Owner's personnel in the maintenance and operation of all equipment and systems. Instructing personnel shall remain on the job continuously during working hours until such instruction is complete, but not less than 16 hours.

C. In addition, refer to Division 1.

1.7 CORRECTION OF WORK AFTER FINAL PAYMENT AND GUARANTEE:

A. This article is supplementary to Guarantee Provisions of Division 1 and General Conditions.

B. Final payment shall not relieve the contractor of responsibility for faulty equipment, materials and workmanship, and unless otherwise specified, the contractor shall remedy any defects due thereto and pay for damage to other work resulting therefrom, which shall appear within a period of one (1) year from the date of acceptance.

C. Include guarantees by the respective equipment manufacturers which shall be subject to the terms and time limits defined under this Article of Specifications.

D. Guarantees furnished by Sub-contractor and/or equipment manufacturers shall be counter-signed by the related Prime Contractor for joint and/or individual responsibility for subject item.

E. Manufacturers' equipment guarantees or warranties extending beyond the guarantee period described herein shall be transferred to the Owner along with the contractor’s guarantees.

1.8 QUALITY ASSURANCE

A. Comply with the requirements of the following codes and/or standards:

1. ANSI.
2. ANSI.
3. UL.
4. NEMA.
5. NFPA.
6. NEC.
7. IBC 2009.
8. BICSI.
9. ANSI/TIA 568-D Series.
10. ANSI/TIA 569-E.
11. ANSI/TIA 606-C.
12. ANSI/TIA 607-D.

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B. All packaged equipment shall be independently Third Party labeled as a system for its intended use by a Nationally Recognized Testing Laboratory (NRTL) in accordance with the OSHA Federal Regulations 29CFR1910.303 and .399, as well as NFPA Pamphlet #70 and National Electric Code (NEC), Article 90-7.

PART 2 - MATERIALS

2.1 MATERIALS AND EQUIPMENT:

A. All installed materials and equipment shall be new and the best of their kind and shall conform to the grade, quality and standards specified herein.

B. Unless otherwise specifically stated, all materials and equipment offered under these specifications shall be limited to products regularly produced and recommended by the manufacturer for the service intended. This material and equipment shall have capacities and ratings sufficient to amply meet the requirements of the project. The capacities and ratings shall be in accord with engineering data or other comprehensive literature made available to the public by the manufacturer and in effect at the time of opening of bids.

C. Equipment shall be installed in accordance with manufacturer's instructions for type and quality of each piece of equipment used. These instructions shall be obtained from the manufacturer and shall be considered part of these specifications. Type, capacity, and application of equipment shall be guaranteed suitable to operate satisfactorily. No experimental material or equipment shall be permitted.

2.2 WORK DESCRIPTION:

A. In general, the work shall consist of but not necessarily be limited to the following:

1. Install Owner's pre-purchased equipment as required.
2. Rough in and make final connections to equipment furnished by Owner or by other Trades.
3. Installation of communications backbone cabling.
4. Installation of communications horizontal cabling.
5. Installation of data racks in MDF and IDF Room locations.
6. Communications interface with Building Management Systems, audio visual, fire alarm, and security systems.
7. Communication UL 497 bonding and grounding second level, with lightning protection.
8. Outside plant low voltage service provider coordination.

2.3 WORK INCLUDED:

A. In addition to work described above under WORK DESCRIPTION, the work shall include but not necessarily be limited to the following:

1. Rigging of equipment and materials related to the Telecommunications Work.
2. Provide and install all telecommunications racks and cabinets.

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3. Provide and install horizontal and vertical cable management.
4. Provide and install horizontal UTP cabling.
5. Provide and install backbone UTP and fiber optic cabling.
6. Provide and install grounding and bonding of all systems in accordance with National Electrical Code and ANSI/TIA-607-D Standards and Requirements
7. Provide testing of installed cabling to support telecom systems.
8. Miscellaneous steel and hangers required for support of Telecom equipment.

2.4 CHASES AND OPENINGS:

A. Provide information to the appropriate trades regarding size and location of all openings and chases as required for the installation of this Telecom Work.

2.5 CUTTING AND PATCHING:

A. Provide all cutting and patching required for work performed under this Contract. No holes may be cut or drilled in structural members without prior approval of Owner's Representative. Cutting shall be done by mechanics skilled in their respective trades.

B. No cutting that may impair the strength of the building construction shall be done. No holes may be drilled in or attachments welded to the beams or other structural members without prior approval from the Owner's Representative. All work shall be done by mechanics skilled in their trade.

C. All patching shall be done in a manner to match appearances and quality of existing surfaces.

D. Provide sleeves for conduits passing through poured concrete decks, footings, walls, etc. Cut all openings for conduits passing through precast concrete or existing concrete masonry. Such holes shall be cut with core drill or similar equipment. Sleeves shall not be cut with hammer or chisel, or with any power tool depending on impact for its cutting power.

2.6 SUBSTITUTIONS:

A. Equipment may be shown or specified in several ways:

1. Manufacturer and catalogue or model number with the words "no substitutions," "no equal," "(manufacturer) only," or words of similar respect. The contractor shall furnish the specified item.
2. Several manufacturers and model numbers listed; or one manufacturer and model number, followed by "equals by (mfr A), (mfr B), (mfr C)," or words of similar respect.

    a. If one of the manufacturers is listed on the drawings, that manufacturer shall be considered the basis of design. If none is so listed, the first manufacturer named in the Specification shall be considered the basis of design.
    b. Where manufacturer's or supplier's name, style and catalog numbers are mentioned in the description of material and equipment in the specifications or on the drawings, it is to be understood that they are for the purpose of setting a standard.

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c. If the contractor elects to furnish equipment other than the basis of design, he shall verify capacities, physical size, weight, electrical requirements, methods of connection to other parts of the system, and all other relevant data.
The contractor shall be responsible for informing the Design Professional of all changes required to other equipment, spaces, structure or systems in order to install the substituted equipment. He shall furnish all required shop drawings or sketches required for Design Professional to evaluate the required changes and shall be responsible for all costs associated with such changes, including costs of design or engineering, if such are necessary, and costs of other trades.

3. Where manufacturer's or supplier's names are listed in conjunction with the manufacturer or supplier that is basis of design, they are given to approve the firm name only. Equipment or material submitted by such firms must meet the detailed technical specifications written for the respective item. The contractor shall be responsible for verifying capacities, physical sizes, weights, electrical requirements, methodology for connections to other parts of the system, etc. The contractor shall furnish all required shop drawings for equipment, and for its connection and installation.

B. If any substituted items are submitted after contracts have been awarded, and there is any question of equality of such items, samples may be required to be submitted both for the item specified and that to be substituted, or further proof of equality may be required to the entire satisfaction of the Design Professional. In no case shall additional remuneration be allowed because of the rejection of a substitute.

C. When the equipment is relocated to a place other than that shown on the drawings, or when equipment other than that specified is used, the contractor shall pay any extra cost of required revisions such as structural steel, concrete, electrical, piping, etc.

D. The Design Professional's costs to evaluate substitutions and to revise Drawings and Specifications because of substitutions will be paid by the contractor.

2.7 SHOP DRAWINGS:

A. Refer to Division 1 and individual specification sections.

B. Furnish shop drawings, catalog cuts, performance data and other required data to the Design Professional for approval for all material and equipment specified hereinafter. Sufficient data shall be submitted to show compliance with the requirements of the plans and specifications. All shop drawings submitted shall be first checked and corrected before submitting for approval. Approval for shop drawings by the Design Professional will not relieve the contractor from responsibility for errors or omissions therein. All such errors or omissions must be made good by the contractor irrespective of any approval by the Design Professional.

C. The following applies to all materials and equipment being submitted for this project. Refer to the individual specification sections for additional submittal requirements.

D. It is the responsibility of the manufacturer’s representative and the installing contractor to thoroughly review all shop drawing equipment submittals and state in writing that the products meet or exceed the design specifications and design intent as indicated on the contract documents, prior to submitting them for review by the engineer.

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E. The General Contractor or Construction Manager shall review and stamp all shop drawings noting the CG/CM review process has taken place and that the shop drawings are in compliance with the design documents, prior to submitting the for review by the engineer. Any shop drawings found to not be in compliance shall be returned to the contractor stating such, with a copy of the statement (only) forwarded to the engineer.

F. On submissions beyond the initial one, clearly identify changes made from the initial submittal other than those requested by the Design Professional will review only those changes that are requested and those identified by the contractor.

G. The Engineer will review three submissions (one original submission and up to two revised submissions) on any single component requested for review. If the contractor and/or vendor fail to comply with the drawings, specifications, and/or review comments, and additional submissions are required, the cost for those submissions will be borne by the contractor.

H. The design documents are based and coordinated on the scheduled manufacturers. Any substitutions of products or materials (from those approved and listed in the specifications) must be thoroughly coordinated by the submitting contractor. This includes but is not limited to power, space, structural, control and performance requirements.

I. Shop drawings required shall include, but not necessarily be limited to, the following:

1. Shop drawings, cuts and catalogue information showing appearance, dimensions, performance, weight, etc., of all equipment, fixtures, appurtenances, etc. See respective equipment or system sections for more specific requirements.
2. Schedules of all materials showing type and manufacturer.
3. Wiring diagrams and schematics for equipment.
4. Telecommunications cabinets, racks, switchboards, panels, and other protective and distribution equipment.
5. All special equipment and systems.
6. Other shop drawings as may be requested.

J. Electronic and facsimile submission of shop drawings will not be accepted as the submittal format. An advanced copy for starting the process may be E-mailed but hard copy submittals shall be submitted for actual review.

K. Product Data: Include manufacturer’s technical literature for each device. Indicate dimensions, capacities, performance characteristics, electrical characteristic, finishes for materials, and installation and startup instructions for each type of product indicated.

L. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Schematic flow diagrams showing all controlled equipment and control devices.
2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
3. Details of control panel faces, including controls, instruments, and labeling.
4. Written description of sequence of operation.
5. Trunk cable schematic showing programmable control unit locations and trunk data conductors.

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6. Listing of connected data points, including connected control unit and input device.
7. System graphics indicating monitored systems, data (connected and cSMSulated) point addresses, and operator notations.
8. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.

M. Shop Drawings shall be submitted and shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Shop drawings shall also contain complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, calculations, and any other details required to demonstrate that the system will function properly. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work.

N. Shop Drawings shall be approved before any equipment is installed. Therefore, shop drawings must be submitted in time for review so that all installations can be completed per the project completion schedule. Ten working days shall be allowed for submittals to be reviewed.

O. All drawings shall be reviewed after the final system checkout and updated or corrected to provide "as-built" drawings to show exact installation. All shop drawings will be acknowledged in writing before installation is started and again after the final checkout of the system. The system will not be considered complete until the "as-built" drawings have received their final approval. The contractor shall deliver a complete set of "as-built" drawings.

Shop Drawing Review Comment Definitions:

A> No Exception Taken:

The shop drawing or equipment submittal as submitted is approved without exception. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required

B> Make Corrections Noted:

The shop drawing or equipment submittal as submitted is not completely correct but is approved as noted. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted can be released for fabrication and construction once the corrections have been made. The submittal must be corrected and resubmitted for record unless noted by "E: Resubmit". See "E: Resubmit definition below.

C> Submit Specified Item:

The shop drawing or equipment submittal as submitted is missing a component of the system that it represents or is not of the approved and specified manufacturers. Submit the missing or incorrect item. The materials, equipment or system submitted cannot be released for fabrication and construction.

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D> No Further Submission Required:

The shop drawing or equipment submittal as submitted is approved as noted. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

E> Resubmit:

The shop drawing or equipment submittal as submitted is not approved. The shop drawing or equipment submittal needs significant corrections and does require another submission to verify that the comments and changes have been incorporated. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted cannot be released for fabrication and construction.

F> Rejected:

The shop drawing or equipment submitted is not as specified or a non-approved manufacturer or product and rejected.

G> Resubmit for Record Only:

Make the corrections noted on the shop drawing or submittal. The shop drawing or equipment submittal as submitted is approved with minor exception. Changes or corrections are required. The materials, equipment or system submitted can be released for fabrication and construction.

PART 3 - EXECUTION

3.1 VISIT TO SITE:

A. Before submitting bid, the contractor shall visit the site of the work and be thoroughly familiarized with the conditions affecting the work. No extra payment will be allowed on account of extra work made necessary by failure to do so.

3.2 WORKMANSHIP:

A. All work shall be installed in a first class, neat and professional manner by tradespeople skilled in the trade involved. All details of the installation shall be mechanically and electrically correct. Should the Design Professional direct removal, change, or installation of any equipments or systems not installed in a neat and workmanlike manner, such charges shall be made by the Electrical Contractor at no expense to the Owner.

B. Equipment shall be installed in strict accordance with manufacturer's instructions for type and capacity of each piece of equipment used. The contractor shall obtain these instructions from the manufacturer and these instructions shall be considered part of these Specifications.

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C. Drawings and specifications have been prepared with best knowledge of conditions available at the time of design. If any obscurities or discrepancies exist, they shall be brought to the attention of the Design Professional before bids are submitted. If they are not discovered before bids are submitted, the Design Professional shall be notified and shall render decision. This decision shall be final.

1. Drawings and Specifications are intended to be complementary; items described or shown in one but not both are to be furnished as if fully shown or described in both locations.
2. In case of conflict between provisions of the Specifications, the more stringent requirement shall govern. Where a requirement is applied to a specific product, condition, system, or Specification Section which conflicts with a more general requirement elsewhere, the specific shall supersede the general.

D. Drawings are generally indicative of the work to be installed, but do not indicate all conduit bends, fittings, boxes, and specialties which may be required, or the exact locations of all conduits. The contractor shall investigate structure and finish conditions affecting the work and arrange this work; accordingly, furnishing such fittings as may be required to meet such conditions. The contractor is responsible for exercising proper judgment to arrange this work and materials so as to avoid interference with other trades.

1. Riser diagrams, details, and schematics generally indicate cabling to be used in various systems involved. This information may or may not be duplicated on the plans, but equipment shown on either plans or riser diagrams and schematics shall be provided as if shown on both.
2. All grades, elevations, dimensions, and clearances of equipment shown on drawings are approximate and shall be verified at site.
3. Where work or equipment is referred to in singular terms, such reference shall be deemed to apply to as many items of work or equipment as required to complete entire installation.

3.3 FIELD MEASUREMENTS:

A. Before ordering any material or doing any work, verify all measurements at the building and site and be responsible for the correctness of same. No extra compensation will be allowed on account of differences between actual dimensions and measurements and those indicated on the drawings. Any difference which may be found shall be submitted to the Design Professional for consideration before proceeding any further with the work.

3.4 DELIVERY OF EQUIPMENT:

A. Be responsible for delivery of equipment, unload, and store in a manner not to interfere with the operation of other trades. Additional expense incurred because of equipment or material delivery delays shall be assumed by the responsible contractor.

NOT FOR BIDDING PURPOSES

3.5 PROTECTION OF WORK:

A. All work, equipment and materials shall be protected at all times. All raceway openings shall be closed with caps or plugs during the installation. All equipment shall be tightly covered and protected against dirt, water, plaster, paint and other foreign material or mechanical injury during entire progress of installation. Make good all damage caused either directly or indirectly by workmen employed to fulfill requirements of the Electrical Work.

3.6 REMOVAL OF RUBBISH:

A. During the course of construction, periodically remove from the premises all rubbish resulting from work of this trade so as to prevent its accumulation. At the completion of the work contemplated under these Specifications remove from the building and site all rubbish and accumulated materials of whatever nature not caused by the other trades and leave work, and equipment free of all foreign matter including plaster, cement, and paint and leave in a clean, orderly, acceptable, and usable condition.

3.7 COORDINATION WITH OTHER TRADES:

A. Work in conjunction with each of the other trades to facilitate proper and intelligent execution of work with minimum interference.

B. Carefully examine all architectural and structural drawings for the building and drawings for electrical trade and mechanical trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit, or equipment. Proper judgment shall be exercised to secure best possible headroom, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment, and conduit, and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.

C. The contractor shall prepare preliminary shop drawings suitable for use in coordinating this work with the work of other trades. The HVAC section will prepare and furnish reproducible prints at an appropriate scale with all trades indicating piping, ductwork and conduit in relation to all structural elements of the construction, including floor elevations; steel locations, size, and elevations; partitions locations; door locations and direction of swing; and all other information required to assure coordination of the electrical, sheetmetal and piping trades and fire protection in relation to the Architectural function of the project. Coordination meetings will be held under the supervision of the Owner's Construction Manager and General Contractor. Each trade shall have proper representation at all coordination meetings for the purpose of detailing, on a reproducible print mentioned above, the exact location and routing of their work.

D. After the conclusion of the coordination at the working meetings, each trade shall sign the coordinated drawing, with copies being distributed by the GC to all contractors and parties concerned, including the Owner. Final shop drawings of all trades shall be in accordance with the coordinated drawing, which final shop drawings shall be submitted for final approval.

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E. If contractor installs work so as to cause interference with work of other trades, he shall make necessary changes in work to correct the condition without extra charge.

F. Dimensional layout plans of equipment rooms shall be made showing all bases, pads and inertia blocks required for mechanical equipment. Include dimensions of bases, bolt layouts, details, etc.

G. The contractor shall furnish all necessary templates, patterns, etc. for installing work and for purpose of making adjoining work conform, furnish setting plans, and shop details to other trades as required.

3.8 COORDINATION OF TELECOMMUNICATIONS CHARACTERISTICS:

A. The contractor shall carefully examine the drawings of all other trades for equipment requiring telecommunications connection and shall ascertain that all telecom characteristics of equipment scheduled thereon matches the service available. If any discrepancies are noted, he shall immediately refer to Design Professional for resolution. If characteristics are correct, the contractor is responsible for ascertaining method of connection, "rough-in" dimensions, correct plug, and receptacle configurations, etc. While Design Professional has made every effort to provide such information as is known at time of design, the contractor shall obtain final data from shop drawings before proceeding.

B. For all equipment of other trades which electrical characteristics are not scheduled on drawings of that trade, the contractor shall assume the responsibility of notifying the General Contractor furnishing such equipment as to the characteristics required; the contractor will be held responsible for correction of all problems arising from failure to do so.

3.9 FIRESTOPPING:

A. All penetrations through fire-resistance-rated floor, fire resistance rated, floor/ceiling assemblies and roof construction and through fire-resistance-rated walls and partitions shall be fire stopped.

B. Penetrations to be fire stopped include both empty openings and those containing cables, pipes, ducts, conduits, and any other items.

C. Fire rating of sealed penetrations shall meet or exceed the rating of the assembly being penetrated.

D. Materials shall be installed in accordance with manufacturer’s recommendations and UL listing.

END OF SECTION 27 00 00

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SECTION 27 05 00

COMMON WORK ELEMENTS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

B. Related Specification Sections:

1. Division 07 – Through-penetration Firestop Systems
2. Division 26 – Common Work Results for Electrical
3. Division 26 – Low Voltage Electrical Power Conductors and Cables
4. Division 26 – Grounding and Bonding for Electrical Systems
5. Division 26 – Hangers and Supports for Electrical Systems
6. Division 26 – Raceways and Boxes for Electrical Systems
7. Division 26 – Identification for Electrical Systems
8. Division 27 – General Requirements for Telecommunications
9. Division 27 – Common Work Elements for Communications Systems
10. Division 27 – Network Communications Systems
11. Division 27 – Two-Way Communications System
12. Division 27 – Audiovisual Systems
13. Division 27 – Nurse Call/Code Blue
14. Division 28 – Common Work Elements for Electronic Safety and Security
15. Division 28 – Physical Electronic Safety and Security
16. Division 28 – Video Surveillance System
17. Division 28 – Security Communication System

C. Reference Symbols:

1. All device symbols are defined by the appropriate symbol schedule on the symbols and abbreviations sheet in the telecommunications systems drawing package. Not all device symbols as indicated may be required for the project.
2. Because of the scale of the drawings, symbols are shown on drawings as close as possible to the mounting location. Contractor shall coordinate exact locations with all drawings and affected trades prior to submittal of shop drawings.

    a. The Contractor shall coordinate exact locations with all security and telecommunications drawings and site plan drawings as well as all affected trades prior to submittal of any shop drawings.

D. Abbreviations:

1.	ACR	Attenuation to Crosstalk Ratio.
2.	ADA	Americans with Disabilities Act
3.	ASTM	American Society for Testing Materials
4.	ASIS	Formerly the American Society for Industrial Security, now known simply

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		as ASIS International
5.	A/V	Audio Visual Systems – For purposes of this specification section A/V systems shall include all Media Management, Video Broadcasting, Intercommunications (Paging/Public Address, Clock, Auxiliary Sound), Video Intercom, Emergency Communications, Mass Notification, Master Antenna (MATV) and Distance Learning Systems
6.	AVI	Audio Visual Systems Integrator: Shall be a qualified contractor experienced in the installation and certification of A/V systems. The AVI contractor shall be responsible for the design, testing, and certification of all audio/visual systems including, but not limited to: Intercommunications, TV Distribution, Audio Visual, Master Antenna and Bi-Directional Antenna systems as well as all structured cabling systems supporting these technologies.
7.	BAS	Building Automation System
8.	BICSI	Building Industry Consultant Services International - International organization whose primary objective is to enhance the reputation and skills of companies and individuals employed in the telecommunications and security industries by ensuring that current and developing standards are maintained.
9.	CATV	Community Antenna Television
10.	CP	Consolidation Point - Local Interconnection Point between horizontal cables from the building IDF/MDF rooms and horizontal cables for the furniture drops.
11.	DDC	Direct Digital Controller / Device Display Controller
12.	DGP	Data Gathering Panel – A component of the Physical Access Control System (PACS) located at each door or portal location that communicates, stores and processes information received from readers, reader modules, input modules, and output modules with the Security Management System CPU and software.
13.	DMZ	Demilitarized Zone – A firewall configuration for securing local area networks (LANs).
14.	DP	Demarcation Point - The point of interface between the Communications Networks, MATV, any Auxiliary Systems, and the associated Service Providers or Public Utilities. Also known as Entrance Facility. Shall also serve as the primary termination point for all incoming OSP cabling as well as the primary main grounding bus-bar for all communications systems. Refer to project documents for exact location and termination requirements.
15.	ELFEXT	Equal Level Far End Crosstalk.
16.	EMI	Electromagnetic interference.
17.	EMT	Electrical Metallic Tubing – Also known as thin-wall conduit.
18.	FACP	Fire Alarm Control Panel
19.	FAS	Fire Alarm System
20.	FCC	Federal Communications Commission
21.	GFCI	Ground fault circuit interrupter.
22.	GUI	Graphic User Interface – A specialized program employing graphical display maps of a facility and/or site which, also provides a manual user interface for all system functions and operations by utilizing control and annunciation icons from dedicated human machine interface terminals.
23.	HMI	Human/Machine Interface – A Computer-operated, video control terminal complying with FCC Part 15 CFR Title 47, Subparts A and B, and shall utilize multiple dynamic GUI based displays for annunciation and control LCD flat panel computer monitor or display screen as defined by related

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		specification sections.
24.	IBC	International Building Code
25.	ICT	Information Communications Technology – For purposes of this specification section ICT shall include all communications systems including but not limited to all Data, Telephone, BAS, Intercommunications (Paging/Public Address), TV Distribution Systems (MATV) and Audio Visual Systems (A/V) Surveillance Systems and IP based Access Control.
26.	ICTI	Information Communications Technology Integrator – Shall be a qualified contractor experienced in the installation and certification of all data, telecommunications. The ICTI shall be responsible for the design, testing, and certification of Data, Telephone communications systems and all structured cabling systems supporting these technologies.
27.	IDF	Intermediate Distribution Frame – The room/space that shall serve as the local termination point for all horizontal and backbone cabling. Also, shall be known as Equipment Room (ER), Horizontal Cross-Connect (HC) or Floor Distributor (FD).
28.	IEEE	Institute of Electrical and Electronics Engineers
29.	IO	I/O Input/Out – Commonly associated with dry contact relay-based digital integration.
30.	IP	Internet Protocol
31.	IR	Infrared
32.	ISO	International Organization for Standardization
33.	LAN	Local Area Network
34.	LCD	Liquid Crystal Display
35.	LED	Light-Emitting Diode
36.	LV	Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
37.	MDF	Main Distribution Frame – The room/space that shall serve as the primary termination point for all backbone cabling to each IDF locations and horizontal connection point for local communication drops. May also serve as a local IDF location as well as the cross-connection and interconnection of all entrance cables from the DP for all PSTN and WAN connections. Also, shall be known as Main Cross Connect (MC), Telecommunications Room (TR) and/or Campus Distributor (CD)
38.	M-JPEG	Motion – Joint Photographic Experts Group
39.	MPEG	Moving picture experts' group
40.	NEC	National Electric Code
41.	NEMA	National Electrical Manufacturers Association
42.	NEXT	Near End Crosstalk
43.	NFPA	National Fire Protection Association
44.	NTSC	National Television System Committee.
45.	NRTL	Nationally Recognized Testing Laboratory
46.	NVR	Network Video Recorder
47.	NVW	Network Video Workstation
48.	OTDR	Optical Time Domain Reflectometer
49.	OSP	Outside Plant – All cabling associated with building services supporting the incoming service connections to Service Providers, Public Utilities, and Wide Area Networks.
50.	PA	Public Address or Building Intercommunications System.
51.	POTS	Plain Old Telephone Service – Analog Telephone Circuit used for the connection of fax machines, BAS and FAS communications devices and

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		shall be wired upstream of the facility's telephone switch.
52.	PSP	Physical Security Professional as registered by the American Society of Industrial Security-International (ASIS)
53.	PSTN	Public Switched Telephone Network – Connection to local telephone utility providing local telephony communications service.
54.	RCDD	BICSI-accredited Registered Communications Distribution Designer
55.	RFI	Request for Information
56.	RGS	Rigid Galvanized Steel conduit – Galvanized steel tubing, with a tubing wall that is thick enough to allow it to be threaded.
57.	TCP/IP	A standard protocol stack on which the Internet and data communications networks operate.
58.	TGB	Telecommunications Grounding Busbar – Located in each IDF.
59.	TIA	Telecommunications Industry Association
60.	TMGB	Telecommunications Main Grounding Busbar – Located at the building DP/MDF
61.	TVSS	Transient Voltage Surge Suppressor
62.	UPS	Uninterruptible Power Supply
63.	UTP	Unshielded Twisted Pair
64.	VoIP	Voice Over IP telephone Network
65.	VPN	Virtual Private Network
66.	WAN	Wide Area Network
67.	WAP	Wireless Access Point
68.	WLAN	Wireless Local Area Network

E. Definitions:

1. Contract Documents: The documents consisting of the Form of Agreement between Owner and Contractor, Conditions of the Contract, (General, Supplementary, and other Conditions), Drawings, Specifications and all Addenda issued prior to the execution of the Contract.
2. Contract Drawings: The drawings that form a part of the Contract Documents that provides the graphical representation of the project requirements intended design and/or performance criteria to be delivered by the Contractor.
3. Reference Drawings: A drawing and/or set of drawings produced by a proprietary supplier, manufacturer, subcontractor, or fabricator included in the Contract Documents for informational purposes, providing specific information related to the installation of related appurtenances, components, devices, hardware, products, and/or systems. Reference Drawings shall also include any Contract Drawings from prior bid packages that may have pertinent information or require coordination of trades related to this contract.
4. Shop Drawings: A drawing and/or set of drawings produced by the contractor, supplier, manufacturer, subcontractor, or fabricator as a detailed representation of the proper installation of the related, appurtenance, component, device, hardware, product, and/or system to be delivered in conformance to the requirements of the Contract Documents.

1.2 SUMMARY

A. This Section contains the overall requirements associated with all Division 27 and Division 28 Specification Sections, and includes the project design intent for all data, voice, and security network communication cabling and equipment related to the installation of the following systems:

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1. Network Communications System
2. Video Surveillance System
3. Physical Access Control System (PACS)
4. Audiovisual System

B. In addition, this section shall address all requirements for submittals, quality assurance, product handling, record documents, project conditions, installation, system performance, demonstrations, testing, and certifications for all scopes of work related to network communication cabling for this project scope of work. Refer to related Division 26, 27 and 28 specification sections and all contract drawings for additional information.

1. The ICTI shall have overall responsibility for all designs, equipment and all technical support related to all Division 27 scopes of work and shall ensure full coordination of all work as required to provide the following fully operational communications network in accordance with all related specification sections and contract drawings.

   a. The ICTI shall be responsible for providing all equipment, devices, system components, final cable terminations, programming, commissioning, and testing of all network communications cabling and equipment in accordance with all related Division 27 specification sections.
   b. All sub-contractors shall meet the minimum technical capabilities, certifications, and licensing requirements as defined by the "Quality Assurance" chapter.

C. The installation, performance, features, functions, software, and programming criteria as specified herein as well as all related Division 27 specification sections have been designed to offer the maximum system efficiency, ease of operation, occupant safety and the protection of equipment as recommended by The Owner and Design Professional.

1. Any deviations from the specified criteria shall be documented, reviewed and agreed to in writing by The Owner and the Design Professional prior to submission of bids. Refer to Division 01, and all related Division 27 specification sections for any substitutions and/or project deviation requests.

   a. The required information shall include but not be limited to: reason for deviation, all differences in performance, operation and function from the herein specified requirements, all benefits and added features to The Owner as a result of the deviations and any additional incurred costs to The Owner for maintenance and long-term ownership.
   b. Failure to provide the Owner and Design Professional with the required information shall result in any shop drawing submissions being returned for non-conformance with the contract requirements.

2. The contractor and all sub-contractors for this work shall have read all of the General Conditions, Special Requirements, General Requirements and all related specification sections and in the execution of all work shall be bound by all of the conditions and requirements therein.
3. Prior to the submission of the Bid any discrepancies or inconsistencies noted within these specifications and/or the project drawings shall be brought to the immediate attention of the Owner and Design Professional.

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D. All device symbols are defined by the appropriate symbol schedules as indicated by the symbol and abbreviation drawing sheets for each discipline. The Contractor shall coordinate exact locations with all architectural, mechanical, electrical, reflected ceiling, furniture drawings and door hardware specifications as well as all affected trades prior to submittal of bids.

1. All symbols are shown on the contract drawings as close as possible to their intended location. Contractor shall coordinate the installation of all equipment, devices, controls, components, cabling conduits/raceways and integration of other systems with all affected trades and specified system integrators. The contractor shall document all coordination requirements at the time of shop drawing submission.
2. Drawings for this work are diagrammatic and intended to convey the extent, general arrangement, and locations of the work. Because of the scale of the drawings, certain basic items such as access panels, conduits, cabinet sizes, penetration sleeves, pull boxes, back-boxes and junction boxes may or may not be shown on the contract drawings. Include all items where required by code and related specification sections for proper installation of all work.

E. Where ambiguity exists between the project specifications and the contract drawings, the superior in system performance regardless of cost shall prevail and shall be delivered by the Contractor at no additional expense to the project.

F. Project specifications and drawings may not deal individually with every part, control, device, component, or appurtenance which may be required to produce the equipment performance for the specified system and/or as required for compliance with all specified systems integration.

1. Include such items and components, as required, for complete operational systems as defined by the project documents, whether specifically indicated or not. The contractor shall be responsible for providing conduits/raceways, cable terminations, controls, systems, equipment, materials, devices, components, electrical power, equipment racks/cabinets, software, programming, commissioning, testing and all appurtenances as well as the integration of any ancillary systems or Owner provided equipment/components/systems.
2. Coordinate with other applicable trades in submittal of shop drawings and the installation of all systems. All shop drawings shall detail space conditions in order to accommodate other concerned trades, all equipment locations are subject to final review by the Owner and Design Professional.

G. Use of Premises

1. General: The Contractor shall have limited use of premises for construction operations only as required to meet the scope of work as delineated by the Contract Documents.
2. The Contractor shall design, prepare, schedule, and coordinate all scopes of work without disruption of any existing system functions or the daily operation of the facility. All communications cabling and equipment shall be installed in such a manner that all new controls, equipment and/or devices shall be installed, programmed, and tested prior to switch over and/or disconnecting of any existing communications systems.
3. The contractor shall coordinate all installation activities so as not to disrupt the daily routines of the facility and shall include any costs related to a phased construction methodology including but not limited all necessary temporary equipment, devices, components, or systems as well as any labor costs associated with any installation, commissioning, testing demolition of any systems required to be performed after normal business hours of the facility.

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a. Contractor shall plan, schedule, and install all communications cabling and equipment in accordance with all requirements of the project construction schedule. Refer to related specification sections for additional information related to project scheduling and facility access.
b. The contractor shall coordinate all installation and demolition activities so as not to disrupt the daily routine of the facility or negatively impact the integrity of the facility's security and life safety measures.
c. Contractor shall demolish all existing network communications systems, cabling, devices, components and/or controls not integrated with the new telecommunications system at the completion of each project phase and only after final acceptance by Owner, Owner Representatives, and the Design Professionals. The removal or demolition of all existing system devices and/or field wiring not incorporated into the new systems shall be performed in such a manner consistent with all requirements of NFPA 70.

1.3 REFERENCES

A. References to industry and trade association standards as well as all building codes are minimum installation requirements. The codes, standards, and agencies listed below shall form a part of this specification section and all work shall comply with the latest adopted standards.

B. Where the contract drawings and specifications mandate a greater requirement or performance than those specified by any of the below referenced codes and standards, the Contract Documents shall then be the governing requirements for this project. The minimum codes and standards to be applied for this project shall be the following:

1. All applicable requirements of NFPA 70 "National Electrical Code" including, but not limited to:

a. Article 250, Grounding
b. Article 300, Part A. Wiring Method
c. Article 310, Conductors for General Wiring
d. Article 725, Remote Control, Signaling Circuits
e. Article 770, Optical Fiber Cables, and Raceways
f. Article 800, Communication Systems

2. National Fire Protection Association:

a. NFPA-72: National Fire Alarm and Signaling Code
b. NFPA-75: Standard for the Protection of Electronic Computer/Data Processing Equipment
c. NFPA 90A: Standard for the Installation of Air-Conditioning and Ventilating Systems
d. NFPA 92A: Standard for Smoke-Control Systems
e. NFPA-99: Standard for Health Care Facilities
f. NFPA-101: Life Safety Code
g. NFPA-130: Standard for Fixed Guideway Transit and Passenger Rail Systems

3. ANSI/TIA Compliance: Comply with the following Electronics Industries Association Standards:

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a. ANSI/TIA-568C: "Commercial Building Telecommunication Standard"
b. ANSI/TIA-569: "Commercial Building Standard for Telecommunications Pathways and Spaces"
c. ANSI/TIA-455: "FOTP-61, Measurement of Fiber or Cable Attenuation Using an OTDR"
d. ANSI/TIA-606: "The Administration Standard for the Telecommunications Infrastructure of Commercial Building"
e. ANSI/TIA-607A: "Commercial Building Grounding and Bonding Requirements for Telecommunications"
f. ANSI/TIA-492A: "Detail Specification for 850-nm Laser Optimized 50-µm Core Diameter/125µm Cladding Diameter Class 1a Graded Index Multi-Mode Optical Fibers"
g. ANSI/TIA-492CAAA: Detail Specification for Single-Mode Optical Fiber

4. Underwriters Laboratories, Inc.:

a. UL 486A: "Wire connectors and soldering lugs for use with copper conductors"
b. UL 1449: "Transient voltage surge suppressors"
c. UL 1581: "Standard for Electrical Wires, Cables, and Flexible Cords"
d. UL 478: "Standard for Electronic Data-Processing Units and Systems
e. UL 83: "Thermoplastic-Insulated Wires and Cables,"
f. UL 910: "Test Method for Fire and Smoke Characteristics of Cables Used in Air-Handling Spaces." Provide products which are UL-listed and labeled.
g. UL 1069: Hospital Signaling and Nurse Call Equipment

5. Federal Communications Commission:

a. FCC Regulations Part 15 Title 47.

6. Institute of Electrical and Electronic Engineers (IEEE)

a. IEEE 802.3 - "Carrier Sense Multiple Access with Collision Detection," and all applicable supplements a through af".
b. IEEE 802.3.u-100 - "Base T/100-Base-TX, Fast Ethernet"
c. IEEE 802.3.z - "Gigabit Ethernet"
d. IEEE 802.3.ab - "1000 Base T"
e. IEEE 802.3.ae - "10 Gigabit Ethernet"
f. IEEE 802.3.af - "Data Terminal Equipment (DTE) Power via Media Dependent Interface (MDI) that"
g. IEEE 802.11.ax - "Wireless Transmission Standard"
h. IEEE 802.11.bt - "Power over Ethernet"

7. ISO/TC - International Organization for Standardization's (ISO) Technical Committee (TC)

a. 21730 - Health informatics - Use of mobile wireless communication and computing technology in healthcare facilities.

8. NEMA/ICEA Compliance:

a. WC-5 - "Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy,"

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b. WC30 - "Color Coding of Wires and Cables," pertaining to control and signal transmission media.

9. ASTM Compliance: Comply with applicable requirements of D-2219 and D-2220. Provide copper conductors with conductivity of not less than 98% at 20°C (68°F).
10. BICSI -TDMM 13th edition
11. ADA Standards for Accessible Design
12. Local Authority Having Jurisdiction
13. National Electrical Manufacturers Association (NEMA)

1.4 SUBMITTALS

A. In addition to all submittal requirements as stipulated by Division 01 specifications sections, the Contractor shall provide all shop drawing submittals in accordance with the following:

1. Owner and Design Professional approval shall be obtained for all equipment and material before delivery to the job site. Delivery, storage, or installation of equipment or material which has not had prior approval will not be permitted at the job site.
2. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings, and other data necessary for The Owner to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify equipment being submitted.
3. Submittals shall be provided as a complete submission; no partial submissions will be accepted. Failure to provide a complete submission shall result in all submittals being returned for resubmission.

   a. In addition to all paper submission requirements as stipulated by Division 01 the Contractor shall also submit one complete set of electronic submittals in a PDF format.

4. No substituted equipment shall be reviewed without prior approval in accordance with the requirements of “substitutions” under Division 1 specification section.
5. Mark the submittals, "SUBMITTED UNDER SECTION_____."

   a. Submittals shall be marked to show specification reference including the section and paragraph numbers.

6. The Contractor shall schedule submittals in order to maintain the project schedule. For coordination requirements refer to Division 01 Specification Sections, which outline basic submittal requirements and coordination. All Division 01 Specification Sections requirements shall be used in conjunction with this specification section.
7. Prior to any submission the contractor shall be responsible for performing the following quality control items to ensure compliance with all project requirements:

   a. Review all Shop Drawings and Product Data
   b. Review all field measurement criteria.
   c. Review all field construction criteria and methodologies.
   d. Review all catalog numbers and similar data.
   e. Review all coordination requirements of affected trades.
   f. Review conformance to all appropriate specification sections.

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8. All shop drawings shall be prepared using latest version of AutoCAD or REVIT, drawn accurately, and in accordance with The Owner's Standards. The Contractor shall not reproduce the Contract Documents or copy standard information as the basis of the technical data, hand drawn mark-ups of the original project drawings shall not be acceptable. Failure to provide a complete set of "contractor prepared" installation drawings at the time of submittal shall result in all submittals being returned for resubmission.
9. Submission Packaging: The Contractor shall organize the submissions according to the following packaging requirements.

    a. Electronic Copy Submission: One complete set of electronic equipment data sheets and drawings submitted in PDF format and collated in two distinct files:

        1) Equipment Data Sheets, equipment schedules, alarm matrixes cable termination spread sheets, and all related pertinent information.
        2) Drawings including all site plans, floor plans, risers, point to point wiring, grounding, installation details and mounting elevations.

    b. Hard Copy Submission: Submit hardcopies of all shop drawings and product datasheets in accordance with the requirements the of Division 01 specifications.

10. The ICTI shall have an RCDD professional review all shop drawings related to network designs, installations, testing, certifications, and structured cabling layouts for communications systems. Failure to provide RCDD sealed shop drawings shall result in all shop drawings being returned for resubmission without any reviews taking place.
11. The Owner's and the Design Professional's review of the shop drawings and/or samples does not relieve the Contractor from compliance with the requirements of the project documents. Unless the Contractor has informed The Owner and the Design Professional in writing of such deviation at the time of submission, has noted the deviation on the shop drawings, and the Owner and the Design Professional has given written approval of the specific deviation to the project document.

    a. All project requirements shall stand. The Owner's and the Design Professional's review does not relieve the Contractor from responsibility for any errors of omission in the submission of shop drawings and/or samples.

12. Submit all system testing, commissioning, and startup procedures to be employed. Include all estimated times for performance of all tests, all test equipment and workforce necessary for testing.
13. Submit all qualifications and certifications in accordance with the requirements as specified elsewhere in this specification section.
14. Submit project schedule outlining the time frames for all equipment with long lead times for equipment deliveries; include all system commissioning, testing, and training time expectations. Project schedule shall be submitted as CPM schedule and shall utilize a software-based project management program.

B. Shop Drawings:

1. All shop drawings shall include sufficient information, clearly presented, to determine full compliance with all project drawings and specifications. Include the following information as applicable for review; failure to provide all information listed below shall result in all shop drawing submittals being returned for resubmission:

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a. All Building Floor and Site Plans.
b. All equipment, devices and components with manufacturer's name(s), model numbers,
c. All equipment, device and component electrical ratings and power requirements
d. All equipment, device, and component performance ratings.
e. All equipment /device cable voltage drop calculations,
f. All dB losses for all fiber optic devices and cabling,
g. All Speaker taps, voltages, and zoning.
h. All equipment rack/cabinet layouts and rack/cabinet sizes.
i. All device-mounting elevations.
j. All device wiring details.
l. All grounding and bonding connections.
m. Complete point-to-point-wiring diagrams for all systems. Include all equipment and wiring termination schedules and/or matrices.

2. Provide a complete set of "contractor prepared" installation drawings. Drawings at the minimum shall consist of floor plans indicating all; passive and active electronic component locations, field devices, device identifications, distribution racks, patch panels, control panels, auxiliary control panels, power supplies, conduit, and cable requirements as well as all 120-volt electrical circuit locations and designations.

   a. Drawings shall include at the minimum the following:

      1) Detailed equipment layouts for all communications rooms. Coordinate all room layouts with affected trades.
      2) Floor plan drawings showing locations of all equipment, devices, equipment cabinets and/or rack locations. Identify type and sizes of all equipment cabinets and/or racks.
      3) All cable tray layouts, and conduit routing of all conduits 2 inches in diameter or greater.
      4) System riser diagrams and single line drawings
      5) Equipment wattage for each location and estimated BTU production.
      6) Detailed equipment layouts for all equipment consoles. Indicate all equipment locations, power connections and installation details.
      7) All equipment mounting hardware/brackets and installation details. Identify type size, load capacities of all mounting hardware/brackets; include all mounting and installation details, all space requirements, any special architectural modifications required.
      8) Outline drawings of all equipment cabinets/racks showing the relative position of all major components, all-wiring and grounding terminations. Include all panel, cabinet and/or rack dimensions.
      9) All grounding and bonding termination points

3. Provide a complete termination schedule of all communications device drop/outlet locations; indicate on the installation drawings all device drops/outlets' unique identification which shall correspond with schedule and drawings.

C. Equipment Submittals:

1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.

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a. Include all equipment data sheets pertinent to equipment provided. All data sheets shall be highlighted and annotated indicating specific equipment and options supplied. Failure to provide the proper annotation of all equipment shall result in submittals being returned for resubmission.

2. Submit complete technical data necessary to evaluate the material and equipment. Include a complete technical specification for the submitted equipment, noting differences and adherence to this Section. Failure to provide the required data will result in all submittals being returned for resubmission.
3. Submit performance data, equipment ratings, cable requirements, control sequences, GUI based control panels, programming matrixes, logic diagrams and all other descriptive data necessary to describe the installation and operations of the system being provided. Failure to provide the required data will result in all submittals being returned for resubmission.
4. Parts list which shall include those replacement parts recommended by the equipment manufacturer, quantity of parts, current price, and availability of each part.

D. Maintenance and Operation Manuals: Submit in accordance with all requirements of Division 01 specification sections and as herein specified.

1. Maintenance and Operation Manuals: Submit as required for systems and equipment specified in the technical sections. Furnish in electronic format. Furnish one complete manual as specified in the technical section but in no case later than prior to performance of systems or equipment test and furnish the remaining manuals prior to contract completion.
2. Inscribe the following identification on the cover: the words "Maintenance and Operations Manual", include the name and location of the system, equipment, building, name of Contractor, and contract number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the system or equipment.
3. Provide a "Table of Contents" and assemble the manual to conform to the table of contents, with tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in.
4. Furnish (1) digital copy of all Maintenance and Operation Manuals in PDF format.
5. The manuals shall include:

a. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.
b. A control sequence describing start-up, operation, and shutdown.
c. Description of the function of each principal item of equipment.
d. Installation and maintenance instructions.
e. Safety precautions.
f. Diagrams and illustrations.
g. Testing methods.
h. Performance data.
i. Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare parts, and name of servicing organization.
j. Appendix; list qualified permanent servicing organizations for support of the equipment, including addresses and certified qualifications.

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6. Approvals will be based on complete submission of manuals together with shop drawings.

1.5 QUALITY ASSURANCE

A. Integrator Qualifications: The projects' Information Communication Technology Integrator (ICTI) shall be an accredited and authorized distributor of the appropriate equipment manufacturer and shall be fully certified in the installation, testing and programming of all equipment being provided.

1. The ICTI shall be capable of providing documented successful work experience of at least three (3) facilities of equivalent size and technical requirements utilizing the proposed equipment being provided and have on staff a minimum of one full time individual that holds a current RCDD registration.
2. Cable Installer Qualifications: The cable installation contractor shall demonstrate not less than three (3) years' experience in the installation of structured cabling systems and shall have on staff a minimum of one full time member that holds a current BICSI level II installer credential.

a. NOTE: The installation of all communications cabling shall be under the direct supervision of a current BICSI level II installer who shall be knowledgeable in the following technical applications:

1) The Routing and installation of shielded, unshielded, twisted pair, coaxial and fiber optic cables.
2) Bonding and grounding of cable tray and equipment racks.
3) Fusion splicing of fiber optic cabling.
4) Testing copper conductors for electrical continuity.
5) Testing and Certifying of UTP structured cabling for attenuation and worst case near end cross talk.
6) Testing and Certifying of ALL fiber optic cabling employing an Optical Time Domain Reflectometer (OTDR) in accordance with TIA protocols.
7) Testing and Certifying of coaxial cable networks for RF leakage
8) Termination, connection, and testing of shielded and un- shielded twisted pair cable, coaxial cabling and fiber optic cabling on all specified connectors, electrical protection blocks, termination blocks and patch panels.
9) Generally accepted industry standards, as well as manufacturers written installation instructions, will be used for in-process quality control and final acceptance of the work installation.

3. The Owner and the Design Professional reserve the right to require the Contractor to submit a list of installations where the products have been in operation before approval.

a. Experience shall be defined as the completion of the specific system being provided, with that system being successfully operated by the Owner for its intended purpose for at least three (3) years.
b. In addition to the above, "Experience" shall also be defined as the completion of modifications and renovations to any associated system being provided in any existing occupied facility of this size and magnitude.
c. For each facility submit the following:

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1) Name and location of facility
2) Date of Occupancy or beneficial use by Owner
3) Owner's representative to contact and telephone number.
4) Construction Manager or General Contractor
5) Project Architect or Engineer
6) Provide information on the installed locations with operational equipment.
7) Registration number and expiration date of RCDD professional
8) Registration number and expiration date of Level II installer.

4. Service Qualifications: The ICTI shall be a permanent service organization maintained and/or trained by the product manufacturer on the products being provided for this project.

a. The ICTI shall be (where required) properly licensed by the governing municipality to provide the services and work for the specific system being installed. In addition, all integrators shall be capable of providing full service for the entire warranty period within an 8-hour response time upon notification of a service emergency.

B. Manufacturer's Qualifications: The manufacturer shall regularly and presently produce, as one of the manufacturer's principal products, the equipment and materials specified for this project, and shall have manufactured the items for at least three years.

1. Product Qualification: The Manufacturer's product shall have been in satisfactory operation, on three installations of similar size and type as this project, for approximately three years.

a. The manufacturers shall submit the appropriate documentation certifying that the project ICTI is a qualified service provider of all manufacturers' products being provided for this project.

1.6 RECORD DOCUMENTS

A. In addition to all general provisions of the Contract, including but not limited to all; General and Supplementary Conditions, Division 01 Specification Sections include the following project requirements:

1. Provide complete set of finalized copies of record documents prior to final acceptance of the project by The Owner and the Design Professional in accordance with all requirements of Division 01 specification sections. At the minimum the record documents shall contain all information, data and drawings as described in Chapter 1.4 "Submittals" of this specification section.

a. As-built documents shall be submitted in both paper and electronic media formats in the quantities as specified by Division 01 specification requirements.

1) All electronic record drawings shall be prepared and submitted utilizing an AutoCAD- or REVIT-based program as manufactured by Autodesk. Where electronic documents are prepared using other than an AutoCAD or REVIT program manufactured by Autodesk, the contractor shall provide to The Owner and Design Professional the necessary software to electronically view the submitted documents.

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2) All electronic data sheets, control sequences, programming matrixes and other descriptive data shall be provided in PDF formatted documents.
3) Copies of all current system programming and associated software shall be provided on downloadable media formatted for the use in restoration all system operations and functionality in the event of a catastrophic failure.

1.7 EXTRA MATERIAL

A. In addition to all general provisions of the Contract, including but not limited to all; General and Supplementary Conditions, Division 01 Specification Sections refer to related specification sections "Extra Material" for specific requirements.

B. All Extra materials shall be provided at the time of final acceptance of the project and a signed packing list shall be obtained at the time of delivery. At no time is the contractor to use the extra materials provided for this project to replace malfunctioning or damaged equipment and or components.

C. Provide 5% of all material as "Extra Material."

PART 2 – PRODUCTS

2.1 MANUFACTURED PRODUCTS

A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, that meet and/or exceed the specified performance and features of the equipment and/or systems and for which replacement parts shall be readily available to the system integrator and/or using agency.

1. When more than one unit, device, or component of the same class of equipment is required, such units, devices or components shall be the product of a single manufacturer.
2. Acceptable manufacturers for each system shall be as specified and shall be provided in full compliance with the requirements of this and all related specification sections and contract drawings.

a. Manufacturers listed as acceptable shall not negate the contractors' responsibility for providing all equipment, devices, components and/or systems, in accordance with all functions and performance requirements of the Contract Documents.
b. Where manufacturer and/or manufacturer model numbers reference specific system components in the related specification sections, it is to establish the performance requirements and quality of the systems and components only.

1) It is in no way an inference that the referenced model numbers are the manufacturer's current product and are the only acceptable components for this project unless specifically referenced as "no substitutions."

c. The Contractor shall provide the manufacturers' most current product that shall meet and/or exceed the specified performance and features of the equipment and/or systems.

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d. Equivalent UL-listed equipment may be substituted for the approved manufacturers unless stipulated by other specification sections as "No Substitutions." All substitutions shall be submitted for approval by The Owner and the Design Professional in accordance with all requirements of Division 01 specification sections and Chapter 1.4 "Submittals" of this specification section.

1) Where systems and/or components are referenced as "no substitutions" the specific system and/or components shall be provided.
2) All substitutions shall comply with all requirements as specified above and all system performance standards shall be maintained.
3) The contractor shall stipulate the following information impacted by such a substitution.

a) Any and all extensions in time impacted by the substitution.
b) Any changes to the architectural or structural elements to the project
c) Differences in operation and/or performance from intended system criteria.

4) Failure to provide the required substitution information shall result in "without consideration" the immediate rejection of the substituted equipment and/or systems.

B. Equipment Assemblies and Components:

1. Components of an assembled unit need not be products of the same manufacturer.

a. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.
b. Components shall be compatible with each other and with the total assembly for the intended service.
c. Constituent parts which are similar shall be the product of a single manufacturer.
d. Factory wiring shall be identified on the equipment being furnished and on all wiring diagrams.

C. Compatibility and Interoperability of System Components and Devices

1. Where multiple components, devices and/or systems are intended to be interconnected and components of a complete system in accordance with any related specification sections, it shall be the Contractor's responsibility to verify interoperability and compatibility of said components, devices and/or systems in full conformance to the specified performance criteria prior to the submission of shop drawings.
2. Where specified devices are found to be incompatible or incapable of performing as specified in a seamless manner, the contractor shall notify the Engineer in writing prior to submission of shop drawings. Failure to properly identify such functional discrepancies shall not relieve the contractor from providing a complete and fully functional system in accordance with the requirements of all related specification sections.

D. Where Factory or Off-Premises Testing of any equipment, product or assembly is recommended by the product manufacturer or where specified as part of this section and/or any related specification section:

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1. The Owner, the Design Professional and/or Owner representatives shall have the option of witnessing all factory tests. The Contractor shall notify The Owner and the Design Professional at a minimum of thirty (30) working days prior to the performance of any factory or off-premises tests.

    a. Where the factory or assembly point for all off-premises testing is not within two (2) hours driving time from the project location, the system integrator shall include as part of this project all per diem costs (travel, meals, and lodging) for a minimum of two representatives from the using agency and the project Design Professional to witness all testing.

2. Provide four (4) copies of certified test reports containing all preliminary test data and testing procedures shall be furnished to The Owner and the Design Professional prior to any final testing and not more than ninety (90) days after completion of any tests.
3. When equipment, product or assembly fails to meet any factory or off-premises tests, retesting of equipment, product or assembly shall be mandated, the manufacturer/integrator shall be liable for all additional expenses, including all expenses incurred by The Owner and the Design Professional for witnessing the retesting of any equipment, product, or assembly.

PART 3 – EXECUTION

3.1 EQUIPMENT PROTECTION

A. Protect all materials, equipment, devices, or components permanently installed and/or stored on the job site. Protect all materials, equipment, cabling, devices, or components during construction and after installation. Provide appropriate protection of all materials, equipment, components and/or devices until time of substantial completion. All materials, equipment, components and/or devices shall be protected during shipment and storage against any physical damage, dirt, moisture, cold, snow, wind, or rain:

1. During installation, enclosures, racks/cabinets, equipment, controls, controllers, circuit protective devices, and other like items, shall be protected against entry of any foreign matter; and shall be vacuum cleaned both inside and outside before testing and operating and repainting if required.
2. Any materials, equipment, components and/or devices, stored on site, which have been deemed by The Owner or the Design Professional to exhibit any indications of damage or exposure dust or moisture shall not be installed and shall returned to the source of supply for immediate replacement.

    a. The use of spare parts or the return of defective equipment for repair to mitigate the damage of defective materials, equipment, components and/or devices shall not be acceptable. All materials, equipment, components and/or devices shall be new and unused until final acceptance by the Design Professional.

3. Provide and apply protective material immediately upon receiving the products and maintain throughout the construction process.

    a. Painted surfaces shall be protected with factory installed removable heavy kraft paper, sheet vinyl or equal.

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b. Any damaged paint on equipment and materials shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired area is not obvious or detectable.

4. Failure to properly protect all materials, equipment, components and/or devices prior to final acceptance shall constitute sufficient cause for rejection of materials, equipment, components and/or devices should any defects, damage or degradation in performance is observed.

B. Seismic Performance: All equipment, bracing, and anchoring shall be rated for the seismic zone of the geographical area in which the project resides and shall withstand the effects of earthquake motion and wind forces in accordance with the current editions of the IBC and ASCE/SEI 7. Refer to Refer to Division 01 and Division 26 – Hangers and Supports for additional seismic information and requirements.

1. Equipment shall include, but not be limited to, racks/cabinets, cable/basket/ladder tray, conduit, cameras, and all appurtenances.

C. Immediately replace all malfunctioning materials, equipment, components and/or devices with new unused products up until the time the Design Professional issues final acceptance of the system. The returning of any malfunctioning equipment, devices and/or components to the manufacturer for repair and then reinstallation at the project site shall not be acceptable.

1. All replacement materials, equipment, components and/or devices shall be factory new and not scavenged from the Project's spare parts inventory or factory recycled products unless expressly identified by contractor prior to replacement and approved beforehand by the Design Professional.

3.2 WORK PERFORMANCE

A. Installation, final termination, testing, start-up and commissioning of all systems, system components and cabling infrastructures shall be under the direct supervision of the appropriate system integrator. The integrator shall be an accredited and authorized distributor of the appropriate equipment manufacturer and shall be fully certified in the installation, testing, commissioning, and programming of all equipment, devices, components and/or systems being provided as part of this project.

B. Job site safety and worker safety is the responsibility of the Contractor. Ensure that safe access and egress from all work areas is maintained during movement and installation of materials. Clean up all debris generated by installation activities. Keep all communication equipment rooms free of debris at all times.

C. Pre-installation Conferences: Include provisions to attend all pre- installation conferences at Project site in compliance with all requirements in Division 01 specification section and as herein specified. Review methods and procedures related to installation and operations of all communications systems, including, but not limited to, the following:

1. Inspect and discuss electrical and equipment roughing-in related to all communications systems as well as other preparatory work required to be performed by other trades.
2. Review and discuss all work, equipment deliveries, installation procedures and related scopes as required to conform to the phased construction schedule.

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3. Review sequence of operations for each type of system, control, cabling and/or integration to any systems and/or equipment provided by other trades
4. Review and finalize construction schedule and verify availability of materials, installation personnel, equipment, and any preparatory work by other trades needed to make progress and avoid delays.
5. Review required start-up, testing, commissioning, and certifying procedures to be employed for each system and any impacts to other trades.

D. For work on existing facilities, arrange, phase, and perform work to assure the operation of all communications systems for other buildings and contiguous spaces at all times. Refer to Division 01 specification section for additional information.

E. All new work shall be installed and connected to existing work neatly and carefully. Disturbed or damaged work shall be replaced or repaired to its prior conditions, as required by Division 01 specification sections.

F. Coordinate the installation of all cabling, conduits/raceways and cable trays and equipment with applicable trades to ensure proper operation and function of all integrated systems in accordance with all related specification sections. Refer to Division 01 specification section for additional project coordination requirements.

1. Coordinate with all trades at the time of shop drawing submission detailing all space and/or room conditions. The contractor shall coordinate with the appropriate trade all conditions impacting the installation of any system, conduit or cable tray including but not limited to all equipment locations, site conditions, ceilings, lighting fixtures, fire protection piping and ductwork layouts to the satisfaction of all concerned trades, subject to final review by the Design Professional.

    a. Coordinate exact location of all desktop/counter/wall mounted equipment with The Owner, the Design Professional, and all affected trades prior to the installation of any equipment and/or cabling.
    b. Coordinate exact location(s) of all cable, conduits, equipment and/or devices installations with all architectural plans, site plans, reflected ceiling plans and affected trades prior to installation.

        1) Equipment installations requiring coordination with other trades the contractor shall provide all templates, back- boxes and equipment anchor bolts for mounting or flush mounting preparation, (e.g., pedestals or other devices requiring mounting on walls, concrete pads, or other materials). Coordinate delivery of templates and equipment anchor bolts to preclude any delay in the construction schedule or the work of the affected trade.

    c. If installation of equipment, devices, cabling, raceways, cable trays and/or conduit is performed prior to coordination with other trades, which interferes with work of other trades or operation and maintenance of the facility, make necessary changes to correct the condition at no additional cost to The Owner.
    d. Prior to the final programming of any systems review with The Owner and the Design Professional all system features, functions, system operations, network mapping, system integrated responses and all related programming as required for the proper operation of the respective communications systems.

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3.3 The Contractor shall maintain a complete set of current and up to date set of shop drawings and equipment submissions at the job site at all times. The Shop drawings and all other submissions shall be marked up to reflect all as-built conditions and shall be made available for review by the Design Professional at request.

3.4 EQUIPMENT INSTALLATION AND REQUIREMENTS

A. All system equipment installations shall be in accordance with good engineering practices, NEC, local building codes, and all manufacturer's requirements. Cable terminations at all equipment locations shall comply with all state and local electrical codes. All wiring shall test free from all grounds, shorts, stray voltages, and EMI.

B. Follow manufacturers' instructions for installing, components and adjusting all equipment and cabling. Submit one (1) copy of such instructions to The Owner and the Design Professional before installing any equipment. Provide an additional copy of such instructions at the equipment during any work on the equipment. Where no instructions are included with the equipment, follow accepted industry practices and workmanlike installation standards.

C. Equipment location shall be as close as practical to locations as indicated on the contract drawings.

1. Provide all equipment clearances in accordance with NEC requirements. Arrange equipment to facilitate unrestricted access for maintenance and service around all equipment, components and/or cable terminations.

D. Inaccessible Equipment:

1. Where The Owner and the Design Professional determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the project.

a. "Conveniently accessible" is defined as being capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit and raceways.

3.5 COMMUNICATIONS CABLING REQUIREMENTS

A. Cabling shall be sized to support the appropriate communication system. All communications cable installations shall be in accordance with good engineering practices as established by the EIA, IEEE, and the NEC. All cabling shall meet all state and local electrical codes.

1. Contractors shall have the option to combine all cable home runs and conductors of same type and voltage "class" in accordance with NEC requirements unless specified elsewhere. Size all conduits and install all conductors in accordance with NEC requirements and manufacturers recommendations.

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a. All communications cabling located above inaccessible ceilings, exposed ceilings, areas outside of tenant spaces shall be installed in conduit and routed to nearest cable tray or J-hook system in accessible ceiling areas.
b. All conduit shall run parallel and perpendicular to building column lines.
c. Cabling installed above hard ceiling spaces shall be installed in dedicated conduits.
d. No exposed cabling will be acceptable in finished or occupied spaces of the facility without approval by The Owner and the Design Professional.
e. Any communications system cabling installed exterior to the building and/or all cabling being routed from the facility to any remote location external to the project location shall utilize OSP rated fiber optic cable installed in conduit system.

2. Do not install bruised, kinked, scored, deformed, abraded, or otherwise damaged cable. Do not splice cable between indicated terminations, taps, or junction points. Remove and discard cable where damaged during installation and replace it with new cable.
3. Ensure that all communications cabling supports (conduits, support grips, cable trays and cable termination panels) are fully installed before proceeding with cable installation.
4. At no time shall any cables be installed and left unsupported, nor shall cables be tie-wrapped to any other supporting structure in lieu of specified cable supports. Do not tie-wrap or permanently affix cable bundles to approved cable supports.

   a. NOTE: Cable bundles shall not be cinched too tightly; all cable ties shall be hook-and-loop (“Velcro”) tie-wraps only.

5. The Contractor shall not permit any communications cabling to lie unprotected on the floor at any time. If cables must be left on any floor, protect the cables so that they may not be walked on or have any material or equipment placed or rolled on top. Replace all damaged cables from demarcation to termination point; no splicing of damaged cables shall be permitted.
6. Maintain manufacturers recommended minimum bend radii of all cabling. Do not stretch, stress, tightly coil, bend or crimp cables. The Contractor shall keep all cabling out of the way of other trades during staging of any work. The contractor at the contractor’s expense will replace all severely stressed or damaged cables, equipment, and materials as determined by the Owner and the Design Professional.

B. Unshielded Twisted Pair (UTP) Cable

1. Refer to specification section 271100 for material.
2. All data TCP/IP based copper network cabling shall be concealed above suspended ceilings, bundled, and independently supported to the building structure. All cabling bundles shall be plenum rated and shall not contain any AC carrying conductors or non-associated network cables.

   a. All cabling shall be terminated onto patch panels matching the rating of the cable and installed in the 19” equipment racks/cabinets.
   b. Copper station cabling may be run outside of conduits and above suspended ceilings only between the cable tray and the conduit wall stub-up.
   c. All horizontal and backbone cable installed above accessible ceilings shall be installed on J-hooks, cable trays, dedicated conduits, or in cable chases and/or a combination thereof as indicated contract drawing or specified. In no case shall cable be supported on ceiling tiles, T-bars, or tie-wrapped to any conduit or pipes.

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1) Cables shall not be cinched too tightly; cable ties shall be VELCRO type tie-wraps only. Plastic wire ties shall not be accepted on any cabling.
2) Horizontal network cabling shall not exceed a maximum distance of 295 feet from the associated communications room termination point to the furthermost work area outlet termination point.
3) Cable Support: Properly secure independently to the permanent building structure where not installed in raceway. Provide J-hooks at regular intervals appropriate to the cable and wire size. See drawing details for spacing requirements.
4) Cables shall not lay loose on ceiling tiles or grids. Cables must be supported in all areas. Bridle rings and tie-wrapped supporting methods are not acceptable.
5) Install all cabling parallel to building lines and follow building structure. Use cable support equipment/hardware recommended by the manufacturer and/or as herein specified.
6) Provide all terminations, cross-connects, wire management, surge protectors, etc. For a complete and operational system.
7) Any copper data communications system cabling installed exterior to the building and/or all cabling being routed from the facility to any remote location external to the project location shall be outside rated (OSP), unless specified otherwise. Outside plant cable shall not extend more than fifty (50) feet into a building interior before terminating on surge protection and transitioning to indoor plenum cable.

C. Fiber Optic Cabling

1. Refer to specification section 271100 for material.
2. All fiber optic cabling shall be provided to meet the communications requirements for all network communications systems, at the minimum all fiber optic cabling shall be sized in accordance with the project documents.
3. All fiber optic cable connectors, terminations and patch panel ports shall be SC/APC-type.
4. All fiber optic cabling shall be a continuous segment from demarcation to termination point. Splices shall not be permitted except at transition points and for termination purposes.
5. All fiber optic cabling shall be installed above accessible ceilings wherever possible.
6. All fiber not installed in conduit or innerduct shall be supported to the building structure and shall be plenum rated armored type cabling installed on J-hooks or in cable trays or shall be standard type fiber optic cable which shall be installed in dedicated conduits.
7. Installation of all fiber optic cabling shall be in accordance with all guidelines established by the product manufacturer and all referenced industry standards.
8. Where fiber cable segments are installed in conduits, special care shall be taken to avoid damage to the cable.

    a. While under pulling tension, the cable shall not be bent into a curve with a radius of less than twenty (20) times the cable diameter, or no less than manufacturers minimum.
    b. Pulling tension shall not exceed manufacturer's recommended maximum tensile load. Contractor shall utilize a winch with tension control, or a "break-away" link designed to break away at or below the recommended maximum pulling tension.

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c. Use methods and lubricating compounds on cables and wires to prevent damage to material and products during pulling-in. Provide compounds that are not injurious to the cable and wire jackets that do not harden or become adhesive.

9. J-hooks supporting fiber optic cabling shall not exceed a maximum of 2 armored fiber cables per 2" J-hook, or 4 per 4" J-hook.
10. Provide a minimum of twenty (20) feet of slack at each end of each fiber optic cable install. Slack shall be neatly bundled in a "figure-8" style loop mechanically secured independent of other systems.
11. All exterior fiber optic cabling shall be rated for exterior outside plant (OSP) applications and installed in dedicated inner-duct conduit system and routed in the exterior conduit ducts in accordance with the requirements of the contract documents. Outside plant cable shall not extend more than fifty (50) feet into a building interior before terminating and transitioning to plenum indoor fiber optic cable.
12. Fiber optic cabling shall be provided as the primary media for any exterior network components installed remote to building, as well as all network communications links for all backbone communications.

    a. The contractor shall be responsible for the determination of actual segment lengths. Actual quantities will be calculated by the routing as indicated on the contract drawings and/or in the field based on existing conditions.

13. All splices shall be fusion type. Mechanical splices shall not be acceptable except for termination purposes.
14. Refer to related specification sections for additional information related to cabling types, sizes, and testing requirements.

D. Environmental Conditions:

1. Systems, components, devices materials and equipment shall be capable of withstanding the environmental conditions of the space without mechanical or electrical damage or degradation of operating capabilities or performance.

    a. Interior, Controlled Environment: System components, installed in temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of 2 to 50 deg C (36 to 122 deg F) dry bulb and 20 to 90 percent relative humidity, non-condensing and shall utilize NEMA 250, Type 1 enclosures.
    b. Interior, Uncontrolled Environment: System components installed in non-temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of -18 to 50 deg C (0 to 122 deg F) dry bulb and 20 to 90 percent relative humidity, non-condensing and shall utilize NEMA 250, Type 4X enclosures.
    c. Exterior Environment: System components, conduits and back boxes installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of -34 to 50 deg C (-30 to 122 deg F) dry bulb and 20 to 90 percent relative humidity, condensing. Rated for continuous operation where exposed to rain as specified in NEMA 250, winds up to 137 km/h (85 mph) and snow cover up to 610 mm (24 in) thick shall utilize NEMA 250, Type 4X enclosures.
    d. Hazardous Environment: System components, conduits and back boxes located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.

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e. Corrosive Environment: System components, conduits and back boxes subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, shall utilize NEMA 250, Type 4X enclosures.
f. Submersible Environment: System components, conduits and back-boxes subjected to prolonged submersion in water, shall utilize NEMA 250, Type 6P enclosures.
g. Areas where equipment and devices may be subject to damage by the general population shall be installed in vandal resistant enclosures; all fire alarm system and related devices shall be provided with wire guards.
h. Console: All console equipment shall, unless noted otherwise, be rated for continuous operation under ambient environmental conditions of 15.6 to 29.4 deg C (60 to 85 deg F) and a relative humidity of 20 to 80 percent.

E. Conduits/Raceway/Cable Trays:

1. Provide conduit and raceway systems for all communications networks as indicated below. Refer to all related specification sections for additional conduit and raceway information.

a. Accessible suspended ceilings: Provide conduit stub-up from each outlet location to space above ceiling. All conduit stub-up shall include nylon bushing at exposed edge of conduit for protection of all cabling.
b. Exposed structure: Provide conduit run from each drop to a height of 12 feet to cable tray or J-hooks where provided.
c. Vertical Wire runway shall be installed in dedicated conduits and shall be supported any/all risers between floors in closets or accessible locations; in no case shall any cable risers be unsupported.
d. Cables entering all communications equipment rooms shall be supported with Cable tray from entrance to rack/cabinet location as indicated on the contract drawings and/or herein specified.
e. Wire basket cable tray system shall be provided in all corridors as indicated on the contract drawings and installed as herein specified.

2. All conduits/raceways shall be concealed and shall be installed above accessible finished ceilings and/or in walls. Any conduits/raceways installed in areas requiring installation to be exposed, shall be installed tight to ceilings and at right angles to walls/building lines and shall not obstruct any access hatches, equipment service panels, lighting or other equipment and/or devices. No exposed conduits/raceways shall be installed without prior approval of The Owner and the Design Professional.

a. Where conduits cannot be concealed above ceilings or in walls and must be installed in finished or occupied areas of the building, all conduits shall be finished wire-mold type raceways or approved equal. Finished wire-mold type raceways shall not be installed without prior approval in writing by The Owner and the Design Professional.
b. Where any equipment and/or junction boxes are installed above non-accessible finished ceilings, the contractor shall provide access hatches listed for the intended application. Access hatches shall be located so that service access to the equipment and/or junction boxes is unimpeded.

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1) Access hatches shall not obstruct any equipment, service panels, lighting equipment, devices, or any architectural elements of the ceiling. At the time of submittals, the contractor shall submit all proposed access hatch locations for review by the Design Professional.

c. All conduits/raceways shall be supported in accordance with NEC requirements and shall be affixed in such a manner that tampering and/or removal without the use of specialized tools shall be prevented.

d. All conduits/raceways shall be installed in a manner that prevents tampering or removal when installed in areas exposed to the general population.

1) Provide tamper-resistant installation utilizing "torx with peg" security-fastening devices for all conduits/raceways, equipment, devices, and appurtenances in all areas accessible to the general population and/or areas subjected to tampering or vandalism.

e. Interior raceways shall be a minimum 1 inch unless otherwise noted. Exterior raceways shall be a minimum 1 1/4-inch. Size all raceways and install conductors in accordance with NEC requirements. Fill ratio shall not exceed 40 percent for indoor or exterior raceways.

1) EMT conduit with compression fittings and/or MC cabling may be utilized in all inaccessible ceiling areas unless otherwise restricted by code.
2) Threaded Rigid metal conduit shall be used on all exterior applications, stub-ups and all interior areas where concealed conduit requirements cannot be met and are exposed to tampering or damage by the general population.

a) All areas considered being of high risk due to the nature of the occupancy or the need to protect and maintain the integrity of the cabling shall be installed in rigid threaded conduits.

f. Conduits shall be continuous. Conduit runs shall not exceed two (2) 90 degree bends and/or 100 feet without a pull/junction box.

g. All conduits and pull/junction boxes shall be concealed in walls or ceilings unless otherwise noted.

h. Conduits shall be connected to pull/junction boxes with set screw connectors and nylon screw on bushings.

i. Conduit inside bend radius for 2" conduits or less shall be 6 times the internal diameter. Conduit inside bend radius for sizes over 2" shall be 10 times the internal diameter. The use of condulets (lb's) is prohibited.

j. Pull/junction boxes shall not be used in lieu of a bend.

k. Firestop all annular space around conduits at through-wall and through-floor penetrations match the rating of the penetrated wall and floor.

l. Field coordinate installation and exact placement with all trades.

m. Conduit expansion couplings shall be provided in all areas where expansion/contraction may occur to couple together two sections of a conduit run subject to longitudinal movement. The contractor shall refer to architectural drawings for exact locations of all building expansion joints. Conduit expansion couplings shall be consistent with the size the conduit being installed, shall be steel electrogalvanized, and shall meet all environmental and seismic conditions.

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1) Expansion couplings shall be weatherproof and approved for use indoors or outdoors without an external bonding jumper.
2) Expansion couplings shall be UL Listed and approved for use in wet locations.
3) Expansion couplings shall comply with UL 514B, CSA 22.2 No. 18 3-12, NEMA FB1.

n. Exterior raceways: PVC schedule 40 conduit at the minimum shall be utilized in all underground applications unless otherwise specified by related specification sections. The conduit shall be buried at a minimum 36" below grade. Warning flagging tape shall be buried 12" below grade to indicate the conduit routing location. Refer to related specification sections for additional information.

1) All exterior conduits larger than 2" in diameter shall be provided with dedicated inner-duct conduit systems, segregated by network type (i.e. security, etc.) and shall include a minimum of one spare empty inner-duct per conduit.
2) The Contractor shall have the option to utilize the same trench/routing location as other utilities. In no case shall any system conduits or duct banks be combined with other electrical utilities without providing the required separation between conduits as necessary to ensure the minimal transmission or conduction of any RF and/or EMI signals.

o. Outlet Boxes: shall be 4 x 4 x 2-1/8 inches deep with single gang reducer plate where required for all data outlet locations and single gang for wall-mounted telephone locations.

1) All outlet boxes shall be provided with single or dual gang device mud-rings flush to finished wall as required based on type and configuration of outlet and type of wall construction.
2) Use deep masonry boxes at masonry construction. T-Bar hangers or other appropriate mounting hardware shall be utilized to support boxes mounted in the ceiling.

3. Cable Trays (Communications Rooms): Provide cable trays in all communications rooms and closets for routing horizontal and vertical distribution and backbone communications cables. All cable trays shall be constructed of aluminum with two side rails and 9" rung spacing. Cable tray shall be complete will all materials, miscellaneous hardware and all appurtenances required for a complete cable distribution and support system.

a. All cable tray widths shall be sized according to the total number of cables to be supported within the various trays plus an additional 100% spare capacity for future expansion capability. At the minimum all cable trays installed in communications rooms and closets shall be a minimum of 12" wide by 1.25" deep, unless otherwise noted.
b. Install cable tray in a manner ensuring that all circuits fully comply with all ANSI/TIA standards.

1) Maintain a minimum clearance of 24" between top of cable tray and ceiling structure or other equipment or raceway.
2) Maintain a minimum clearance of 12" between bottom of cable tray and top ceiling grid or other equipment or raceway.

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3) Maintain a minimum clearance of 24" from all conduits or cables used for electrical power distribution.
4) Maintain a minimum clearance of 12" between bottom of cable tray and top of equipment racks and/or cabinets.
5) Maintain a minimum clearance of 24" from fluorescent lighting. All Pathways shall cross perpendicular to fluorescent lighting and electrical power cables or conduits.
6) Cable tray supports shall be attached to the structural ceiling or walls with hardware or other installation and support aids specifically designed for the cable tray and designed to support the cable tray's weight and required cable weight and volume.
7) Do not attach cable tray supports to ceiling support system or other mechanical support systems.
8) Load span criteria: Install tray supports in accordance with the load criteria of L/240.
9) Cable Trays shall be supported at 5-foot intervals.
10) All Cable trays shall be installed without burrs, sharp edges, or projections, which may damage cable insulation.
11) All lengths or sections of cable tray shall be bonded and grounded in accordance with NEC, EIA/TIA, IEEE.

c. Follow manufacturers' instructions for installing, components and adjusting all equipment and cabling. Submit two (2) copies of such instructions to the Architect before installing any equipment. Provide a copy of such instructions at the equipment during any work on the equipment. Where no instructions are included with the equipment, follow accepted industry practices and workmanlike installation standards.

F. Penetrations of Walls and Floors:

1. All wall/floor penetrations are to be sleeved and fire stopped with approved fire stopping material or sealant as applicable for the type of penetration. Coordinate all cable and conduit penetrations of building with all affected trades. Refer to all related specification sections for additional wall/floor penetration requirements.

a. All penetrations of rated walls and floors shall be firestopped in accordance with the ASTM and NFPA standards. Refer to related specification sections for additional information.
b. Floor penetrations shall be sleeved with a minimum sleeve diameter of 4 inches. An additional penetration shall be provided for future use, sleeved, and capped and fire stopped as required.
c. Coordinate size of wall penetration with conduit size, number of conductors. Comply with all NEC requirements.
d. The fire rating of all penetrated walls, floors, and ceiling structures shall be strictly maintained. All penetrations shall be firestopped and sealed by the Contractor.
e. Install firestopping in open penetrations and in the annular space of penetrations for fire-rated barriers.
f. Installation of firestops shall be performed by an applicator/installer qualified and trained by the manufacturer. Installation shall be performed in strict accordance with manufacturer's detailed installation procedures.

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g. Installation of all firestopping shall be in accordance with fire test reports, fire resistance requirements, acceptable sample installations, manufacturer's recommendations, local fire and building authorities, and applicable codes and shall be installed in a manner acceptable to the authority having jurisdiction.

3.6 ELECTRICAL POWER DISTRIBUTION

A. Refer to division 26 contract documents for circuiting information.

B. Refer to specification section 271100 for UPS and PDU material.

3.7 TRANSIENT VOLTAGE SUPPRESSION

A. Transient Voltage Surge Suppression: All cables and conductors extending beyond building façade, except nonconductive fiber optic cables, which serve as communications, control, or signaling circuits shall be protected against Transient Voltage surges and have Transient Voltage Surge Suppression (TVSS) protection.

1. The TVSS device shall be UL listed in accordance with Standard TIA 497B installed at each end. Lighting and surge suppression shall be a multi-strike variety and include a fault indicator.
2. Protection shall be furnished at the equipment and additional triple solid state surge protectors rated for the application on each wire line circuit shall be installed within 914.4 mm (3 ft) of the building cable entrance. Fuses shall not be acceptable for surge protection applications. All inputs and outputs shall be tested in both normal mode and common mode to verify there is no interference at the minimum surge suppression test shall meet the following criteria.

a. All system power supplies serving exterior system components or devices shall be provided with the appropriate transient surge suppression protection on both the line side as well as the load side.

1) A 10-microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes shall be the minimum performance requirements. Provide surge suppression in accordance with all manufacturers' requirements.
2) An 8-microsecond rise time by 20-microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes shall be the minimum performance requirements. Provide surge suppression in accordance with all manufacturers' requirements.
3) Maximum series current: 2 AMPS. Provide units manufactured by Advanced Protection Technologies, model # TE/FA 10B or TE/FA 20B or approved equal.
4) Operating Temperature and Humidity: -40 to 85 degrees C (-40 to 185 degrees) shall be the minimum performance requirements. Provide surge suppression in accordance with all manufacturers' requirements.

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3.8 GROUNDING AND BONDING

A. All electronic equipment, conduits, cable trays, racks/cabinets and cable shields shall be properly grounded and bonded in accordance with all requirements of EIA/TIA 607-A, NEC 250 and IEEE 1100. Where identified as applicable to the project, all equipment grounding and bonding shall be in accordance with all related specification sections and Motorola R56 Standards and Guidelines for Communications Sites.

1. A Telecommunications Grounding System shall be installed in all communications equipment rooms. Grounding system shall provide equalization of the grounding potentials between the building power system and the telecommunications main grounding bus-bar (TMGB) as well as all telecommunications grounding bus-bars (TGB). Grounding bus-bar shall provide the diversion of electrical transients from the telecommunications cables and to provide a safety ground for all equipment racks/cabinets, conduits, cable trays and cable shields as well as providing the required coupling to cancel and/or reduce transients.

    a. The TMGB and each TGB shall be provided where indicated on the drawings and shall provide an effective bonding connection to the nearest approved building grounding electrode (e.g., structural steel) as well as to the local power distribution panel grounding system (e.g., ac branch circuit panel board's equipment grounding busbar).

        1) The minimum bonding shall be #6 AWG copper conductor connected to the TMGB and all TGB's. Connections shall be 2-hole NEMA type compression or exothermic welded connections.

2. All grounding connections shall provide the equalization of all grounding potentials between the building power system and the grounding terminations at the communications equipment in order to provide the diversion of electrical transients as well as providing the necessary coupling in order to cancel and/or reduce any voltage transients.

    a. Equipment Grounding: Metallic structures, equipment racks, cabinets, and enclosures as well as all raceways, cable trays, junction boxes, outlet boxes, machine frames, and other conductive items shall be bonded and grounded.
    b. Duct Banks and Manholes: Provide an insulated equipment grounding conductor in each duct containing any voltage conductors, sized per NEC except that minimum size shall be No. 2 AWG. Bond the equipment grounding conductors to the grounding bus, to all manhole hardware and ground rods, to the cable shielding grounding provisions for all cable splices, terminations, and equipment enclosures.
    c. Metallic Fences equipped with communications equipment: Fences shall be grounded with a ground rod at each fixed gate post and at each corner post.

        1) Drive ground rods until the top is 300 mm (12 inches) below grade. Attach a No. 4 AWG copper conductor, by exothermic weld to the ground rods and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 300 mm (12 inches) of fence mesh and fasten by two approved bronze compression fittings, one to bond wire to post and the other to bond wire to fence.
        2) Each gate section shall be bonded to its gatepost by a 3 by 25 mm (1/8 by one inch) flexible braided copper strap and ground post clamps. Clamps shall be of the anti- electrolysis type.

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3. All connections of grounding conductors to ground rods, bus bars, rebar, structural members, pipes, and fences, as well as splices of any ground conductors, shall be made by exothermic welds except where otherwise noted. All connections to bar lugs shall be exothermic weld or compression type connections. Bolted type connection of ground conductors may only be made where terminal lugs or blocks have been furnished and installed in equipment by the manufacturer.

    a. Equipment grounding conductors shall be insulated stranded copper, except for sizes No. 10 AWG and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes No. 4 AWG and larger shall be permitted to be identified per the NEC.

        1) At the minimum bonding connection shall be a #6 AWG copper conductor. All grounding shall provide an effective bonding connection between the protected equipment to the nearest approved building grounding electrode (structural steel) as well as to the local power distribution panel grounding system (e.g., ac branch circuit panel board's equipment grounding busbar). All bonding and grounding connections shall be NEMA type compression or exothermic welded connections.

4. Refer to related specification sections for any additional grounding and bonding requirements.

3.9 EQUIPMENT IDENTIFICATION

A. Identify all system controls, components and equipment cabinets using plastic laminate engraved ("limacoid") labels or approved equal. Firmly affix to the panel, device and/or component. Refer to all related specification sections for additional information.

1. Nameplates shall be laminated black phenolic resin with a white core with engraved lettering, a minimum of 6 mm (1/4 inch) high. Secure nameplates with screws. Nameplates that are furnished by manufacturer as a standard catalog item or where other method of identification is herein specified. Dymo or Kroy tape adhesive-backed lettering shall not be acceptable.
2. Color-code all junction boxes and enclosures per NEC recommendations. At the minimum provide all communications junction boxes as follows:

    a. Color for Data/Telecommunications circuits - Yellow.
    b. Color for Audio/Visual circuits – White
    c. Letter all pull boxes and junction boxes located in service areas, tunnels, above accessible ceilings, and pipe chases with laminated black phenolic resin with a white core with engraved lettering, a minimum of 6 mm (1/4 inch) high. Secure nameplates with screws.

3. Permanently label all cabling at both ends with self-adhering plastic labels.

    a. Labeling: hand-written labels are not acceptable. All labels shall be machine printed on clear or opaque tape, stenciled onto adhesive labels, or type written onto adhesive labels. The font shall be at least one-eighth inch (1/8") in height, block characters, and legible.

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1) The text shall be of a color contrasting with the label such that it may be easily read. If labeling tape is utilized, the width of the tape shall not exceed 3/8," and the font color shall contrast with the background.
2) All data patch panels shall exhibit data drop numbers, in sequential order, for all workstations served by the associated network equipment.
3) Each fiber optic cable segment shall be labeled at each end with its respective communications network identifier.
4) Warning Tags: At each location where the fiber cable is exposed to human intrusion, it shall be marked with warning tags. These tags shall be yellow or orange in color and shall contain the warning: "CAUTION FIBER OPTIC CABLE." The text shall be permanent, black, block characters, and at least 3/16" high.

    a) A warning tag shall be permanently affixed to each exposed cable or bundle of cables, at intervals of not more than five (5) feet. Any section of exposed cable which is less than five (5) feet in length shall have at least one warning tag affixed to it.

4. Provide typewritten circuit directories installed in 3-ring binders with transparent page protectors in each control and sub control cabinet and/or equipment rack.

3.10 WARRANTY

A. Warrant material and workmanship for a period as specified in Division 1 of the contract documents and all related specification sections. The warranty period shall commence from the date the Contactor received written notification of final acceptance from the Owner's Representative. At the minimum the contractor shall provide warranty provisions:

1. Warrant the replacement of defective components/materials and/or correct defective work when given notice by the Owner's Representative during the warranty period.

    a. At no time is the contractor to use the extra materials provided under the scope of this project to replace malfunctioning or damaged equipment and or components. The Contractor shall replace all malfunctioning or damaged equipment and or components with new. The repair and then reinstallation of malfunctioning or damaged equipment shall not be acceptable.

2. Warranty excludes liability for consequential incidental, or special damages due to vandalism, misuse, or acts of God.
3. On-site warranty response time by qualified technician shall be within 8 hours upon receipt of request from Owner.
4. Warranty repairs shall be provided to the Owner at no cost. This shall include but not limited to replacement of all defective components/materials, all labor charges, all travel costs, and all vehicle charges.
5. Response time shall be 7 days a week / 24 hours a day / 365 days a Year.
6. Provide test, inspection, and service of each system on a semi-annual basis at six month intervals.
7. Contractor must provide verification that they maintain their principle base of operation along with the personnel that will be responsible for providing service within 3 hours driving time to the project site. This tenet of the warranty shall remain in effect for the life of the warranty.

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8. All TCP/IP based communications systems cabling, and related appurtenances shall be provided with the manufacturers 25 year extended warranty in addition to all requirements above.

B. The Contractor shall, as a condition of final payment, execute a written warranty certifying all contract requirements have been completed according to all requirements of the Contract Documents.

1. All system testing, commissioning, demonstration, and training shall be performed prior to final system acceptance. All defects or damages due to faulty materials or workmanship shall be replaced without delay, to the satisfaction of the Owner's Representative, at the Contractor's expense.

a. The contractor shall provide written documentation of test results and stating what was done to correct any deficiencies. The first inspection shall occur 90 calendar days after the acceptance date. The last inspection shall occur 30 calendar days prior to the end of the warranty.
b. The warranty period shall be extended until the last inspection and associated corrective actions are complete. Where any equipment and/or labor covered by Contractor's or manufacturer's warranty, has been replaced, due to failure, the warranty period for any replaced equipment or restored work shall be reinstated for a period equal to the original warranty period, and commencing with the date of completion of the replacement or restoration work.

2. In the event any manufacturer customarily provides a warranty period greater than one (1) year, the Contractor's warranty shall be for the same duration for that component.

3.11 FIELD SERVICES AND TESTING

A. Notify the Owner and the Design professional in writing, prior to the closing of any ceilings and ten (10) days advance of testing all system cabling to prevent delays in construction schedules.

1. Test all cabling to confirm that no grounds, shorts, sneak currents, RFI and EMI conditions exist prior to start-up and commissioning of all, components, devices, equipment and/or systems.

a. Before requesting a final inspection, the contractor shall perform a series of end to end installation performance tests. The contractor shall submit for approval by the Project Engineer and Design Professional all test procedures to be employed, test result forms, and timetable for testing all fiber optic and structured copper wiring.
b. Acceptance of the simple test procedures discussed below is predicated on the contractor's use of the recommended products including but not limited to, fiber optic cable, category structured cable, cross-connect blocks, patch panels, and outlet devices specified and adherence to the inspection requirements and practices set forth. Acceptance of the completed installation will be evaluated in the context of each of these factors.

B. Balanced Twisted Pair Cable Testing

1. Minimum Test Parameter requirements for Category horizontal cabling.

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a. Each wire/pair shall be tested at both ends for the following utilizing Contractor generated test results forms:

1) Wire Map.
2) Length.
3) Insertion Loss.
4) Near-end crosstalk (NEXT) loss.
5) Power sum near-end crosstalk (PSNEXT).
6) Equal-level far-end crosstalk (ELFEXT).
7) Power sum equal-level far-end crosstalk (PSELFEXT).
8) Return loss.
9) Propagation delay.
10) Delay Skew.
11) Power Sum ACR.

b. All balanced twisted pair cable testing described herein shall exceed specified cabling transmission requirements of ANSI/TIA-568-C.

2. When errors are found, the source of each error shall be determined, corrected, and the cable re-tested. All defective components shall be replaced and retested. Defective components not corrected shall be reported to The Owner and the Design professional with explanations of the corrective actions attempted.
3. Test records shall be maintained using the approved test result forms. The form shall record closet number, riser pair number or outlet ID, outcome of test, indication of errors found (e.g., a, b, c, d, or e) cable length, re-test results after problem resolution and signature of the technician completing the tests.
4. Test results for each cable must be submitted with identification to match labels on all patch panel ports and 8 position modular jacks, and identification to match as- built drawings associated with that cable.
5. The Owner and the Design Professional shall observe and verify the accuracy of test results submitted.
6. Contractor shall submit both hardcopy printouts and electronic copy of all trace test results.

C. Fiber Optic Testing

1. Contractor shall test each fiber strand. The Owner and the Design Professional reserve the right to have a representative present during all or a portion of the testing process. If the Owner and the Design Professional elect to be present during testing, test results will only be acceptable when conducted in the presence of The Owner and the Design Professional.
2. Fiber optic cable: each fiber strand shall undergo bi-directional testing for signal attenuation losses.

a. Test Equipment

1) Optical Power Meter (OPM)
2) Optical Time-Domain Reflectometer (OTDR)

b. Tests:

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1) All fiber strands shall be tested for attenuation using an Optical Power Meter in both directions at 1310 nm and 1550 nm.
2) Test all fiber cable on the reel before installation, with a light source and an OTDR if necessary, to ensure fiber continuity and no factory defects.

3. Fiber Optic Testing Specifications

a. All testing shall be performed by factory trained and certified personnel.
b. For all installed fiber optic cable EIA 455-171 Method D procedures will be adhered to (Bi-directionally).
c. Loss Limits:

1) Connector loss shall not exceed 0.5 dB per connector pair.
2) Cable loss shall not exceed 1.0 dB per kilometer tested at 1310 nm and 1550 nm for premises/inside plant single mode fiber optic cable.
3) Cable loss shall not exceed 0.5 dB per kilometer tested at 1310 nm and 1550 nm for outside plant single mode fiber optic cable.
4) Fiber optic cable tests shall meet all other requirements as specified in TIA 568.C.

d. The contractor is responsible for obtaining minimum loss in fiber connections.
e. Pre-installation tests of Inter-plant fiber: pre-test each reel:

1) Test each fiber strand of each reel for continuity with a light source.
2) If a problem is found, test with an OTDR to determine the nature and location of the defect: Measure end-to end attenuation and the distance to a high attenuation point.
3) If it is determined by Design Professional that the fiber is defective the contractor shall contact the manufacturer and provide a completely new fiber reel.

f. Tests for installed Inter-plant and Intra-plant fiber optic cable:

1) Intra-plant and Inter-plant Single-mode: Bi-directional signal attenuation at 1310 and 1550 nm power meter.
2) Inter-plant Single-mode: Bi-directional OTDR trace at 1310 and 1550 nm. OSP ONLY

NOTE: Obtain the actual index of refraction from the cable Manufacturer before testing.

g. Single-mode backbone links shall be tested as listed above and in accordance with ANSI/TIA-526-7, Method A.1, using not more than one reference jumper. All multimode backbone links shall be tested at 850 nm and 1300 nm in accordance with ANSI/TIA-526-14A, Method A.1, using not more than one reference jumper.

4. Power and Link Loss Budgets

a. Contractor shall prepare and submit a fiber optic power and link loss budget report for all backbone fiber optic cabling links as part of shop drawing submissions.
b. The report shall include the Power Budget, Link Loss, and Power Margin utilizing industry-standard formulas for each backbone fiber optic link.

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c. Submit all test reports for approval; an OTDR trace/signature report for every optical fiber strand and a fiber optic link attenuation record report for every cable by strand.

D. Notify the Owner and the Design Professional in writing, ten (10) days advance of testing of all equipment and/or components to prevent delays in construction schedules.

1. Perform all tests, as required, by authorities having jurisdiction throughout the facility.
2. Test system for grounds to demonstrate that the ground resistance does not exceed the requirements of the National Electric Codes (NEC).
3. Test all cabling to confirm that no grounds, shorts, sneak currents, RFI and EMI conditions exist prior to start-up and commissioning of all, components, devices, equipment and/or systems.
4. Test all systems and components for proper function and operation; certify that all systems are in proper working operation in accordance with the Contract Documents prior to scheduling any system demonstrations.
5. Test all fiber optic cabling as shown in Section C above.
6. Testing of all communications systems shall be in the presence of The Owner and the Design Professional (if they so choose) as well as all appropriate representatives of the authorities having jurisdiction.

   a. All completed communications systems shall be fully tested in accordance with all requirements of TIA. Upon completion of a successful testing, the contractor shall so certify in writing to The Owner and the Design Professional that all testing was completed, certified, and left in first-class operational condition, include all completed copper and fiber testing read-outs, certifications, and test reports.
   b. The service of a competent, factory-trained engineer or technician authorized by the equipment manufacturer shall be provided to technically supervise installation and participate during initial system programming, start-up, final testing, assist in the final acceptance testing and demonstrations.

7. Provide all testing, commissioning and certifications as specified by Division 01 and this specification section, as well as any manufacturer's recommendations or requirements.

E. Tester Criteria

1. General

   a. Tester shall employ a modular platform with a minimum of a 2.0 Ghz processor.
   b. Tester shall be Level IV/V ETL Verified.
   c. Tester shall have hot swappable fiber modules and employ modules for:

      1) Multi-Mode capable of testing at 850 & 1300 nm
      2) Single Mode modules capable of testing at 1310 & 1550 nm

   d. Tester shall have a current calibration date. If testing will go past calibration date, contractor shall have tester re-calibrated.
   e. Tester shall be running current firmware.
   f. Tester will be capable of performing 1,2 & 3 jumper set reference. One jumper is recommended.
   g. Set reference shall be done with factory provided test reference cords (TRC's)

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2. Manufacturers:

    a. Softing WX4500
    b. Fluke Versiv
    c. Or equivalent

3. The field-test instrument shall be within a 12-month calibration period.
4. Certification tester

    a. Accuracy

        1) Level IV/V accuracy in accordance with ANSI/TIA-1152-A
        2) Independent verification of accuracy shall be provided.

5. Permanent Link Adapters

    a. RJ45 plug must meet the requirements for NEXT, FEXT and Return Loss in accordance with ANSI/TIA-568-C.2 Annex C
    b. Contractor shall perform a successful set reference prior to the start of any project.
    c. Twisted pair Category 5e, 6, 6A, cords are not permitted as their performance degrades with use and can cause false Return Loss failures.

6. Results Storage

    a. Must be capable of storing > 5000 results for all measurements.

7. PC Software

    a. eXport or LinkWare PC

8. Reporting:

    a. Tester shall be capable of exporting raw data files in native format.
    b. Reporting Software shall be capable of producing.

        1) Detailed Fiber Certification reports in .PDF format
        2) Summary fiber reports in .PDF
        3) Fiber reports in CSV format.

3.12 TRAINING

A. In addition to all demonstration and training as specified by Division 01 specification section and all related Division 27 specification sections, system demonstrations and training shall be provided in accordance with all requirements of this section.

1. Prior to acceptance of the work, the System Integrator shall demonstrate to The Owner and the Design Professional, all systems and sub-systems all features and functions of each system and shall instruct The Owner’s Representatives in the proper operation, event sequences, programming and maintenance of all systems and sub-systems.
2. The ICTI shall furnish the necessary trained personnel to perform all demonstrations and instructions and arrange to have the manufacturer's representatives present to assist with the demonstrations.

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3. Training time shall include, as a minimum, the total time determined by the sum of the times per system as specified in this and related specification sections, for performing the prescribed demonstrations/training. Refer to related specification sections for additional training requirements.

    a. Allow a minimum of 16 hours' time for each system provided for performing the prescribed demonstrations/training.

4. Provide operation, parts and maintenance manuals defining operation and troubleshooting methods of all systems and review with The Owner's User/Operators as part of training demonstrations.
5. Provide detailed video recordings in high quality digitally formatted media of all demonstration and training of all systems and system operations.

    a. Utilize remote microphones as may be required to ensure high quality audio of the recorded demonstrations.
    b. Permanently and professionally label all recorded materials and provide self-sealing plastic cases.

B. Inspections

1. At the completion of the project and prior to final acceptance of the Work, provide evidence of final inspections and approvals to The Owner and the Design Professional, in accordance with all requirements of the Contract Documents as well as required by the authorities having jurisdiction.

END OF SECTION 27 05 00

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SECTION 27 11 00

NETWORK COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

B. Related Sections:

1. Division 07 – Through-penetration Firestop Systems
2. Division 26 – Common Work Results for Electrical
3. Division 26 – Low Voltage Electrical Power Conductors and Cables
4. Division 26 – Grounding and Bonding for Electrical Systems
5. Division 26 – Hangers and Supports for Electrical Systems
6. Division 26 – Raceways and Boxes for Electrical Systems
7. Division 26 – Identification for Electrical Systems
8. Division 27 – General Requirements for Telecommunications
9. Division 27 – Common Work Elements for Communications Systems
10. Division 27 – Network Communications Systems
11. Division 27 – Two-Way Communications System
12. Division 27 – Audiovisual Systems
13. Division 27 – Nurse Call/Code Blue
14. Division 28 – Common Work Elements for Electronic Safety and Security
15. Division 28 – Physical Electronic Safety and Security
16. Division 28 – Video Surveillance System

C. Reference Symbols:

1. All device symbols are defined by the appropriate symbol schedules. Because of the scale of the drawings, symbols are shown on drawings as close as possible to the mounting location.

a. Contractor shall coordinate exact locations with all architectural drawings, site plans, reflected ceiling plans, furniture plans, mechanical and electrical drawings as well as all affected trades prior to submittal of any shop drawings.

D. Abbreviations:

1. Refer to Specification Section 27 05 00 for additional information.

E. Definitions:

1. Refer to Specification Section 27 05 00 for additional information.

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1.2 SUMMARY

A. The intent of this specification is to establish a standard of quality, overall system configuration and equipment requirements for the installation of a new structured cabling system and audio/visual equipment in support of a facility TCP/IP network and specified Audio/Visual systems. The contractor shall be responsible for providing all design, installation, programming, commissioning, testing and certifications as necessary to provide complete infrastructure to support all TCP/IP telecommunications networks in accordance with the Contract Drawings and/or as herein specified.

B. All communications network cabling for TCP/IP-based Security systems as specified in Division 28 shall also meet the requirements of this section.

1. The installation, performance, features, functions, software, and programming criteria as specified herein as well as all related specification sections have been designed to offer the maximum system efficiency ease of operation, occupant safety and the protection of equipment as recommended by the design Professional.

a. Any deviations from the specified criteria shall be documented, reviewed, and agreed to in writing by The Owner and the Design Professional prior to submission of bids. Refer to Division 01, Division 28, and all related Division 27 specification section for product substitutions.

2. It is the responsibility of the contractor to ensure that the installed system meets or exceeds every standard set forth in these specifications. The contractor shall provide all cabling, communications outlets, conduits, system components, termination equipment, racks/cabinets, emergency electrical power, software, programming, and all appurtenances as well as all necessary testing, commissioning and certifications as required to provide a complete and fully operational TCP/IP based network, whether such items are specifically included in this section or not.

C. The contractor shall furnish all labor, equipment, materials, testing, commissioning, programming, and certification in connection with the installation of a complete premises communications network system as indicated on the drawings and as herein specified.

1. The systems shall be complete with all equipment as indicated on the contract drawings and/or described herein.

a. The systems shall include at the minimum but not limited to the following:

1) Plenum rated cabling.
2) Fiber Optic Cabling (Network Backbone)
3) Coaxial Cabling (MATV/CATV distribution)
4) Conduit/Duct/Raceway/Cable Tray Systems
5) Distribution/Termination Patch Panels
6) Equipment Racks/Cabinets
7) Communications Outlets/Jacks
8) Equipment bonding and grounding.

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D. The contractor and all sub-contractors for this work shall have read all of the General Conditions, Special Requirements, General Requirements and all applicable related specification sections and in the execution of all work shall be bound by all of the conditions and requirements therein.

E. Prior to the submission of the Bid, any discrepancies or inconsistencies noted within these specifications and/or the project drawings shall be brought to the immediate attention of The Owner and the Design Professional.

1. Project specifications and drawings may not deal individually with every component, control, device, or appurtenance, which may be required to produce the specified system configuration, and/or as necessary to meet the equipment and cabling requirements. Coordinate all integration requirements with The Owner and the Design Professional and all appropriate systems providers.
2. Because of the scale of the drawings, symbols are shown on drawings as close as possible to the mounting location. The contractor shall coordinate the installation of all cabling, materials, equipment, devices, jacks, cable trays and conduits with all affected trades and document all coordination at the time of shop drawing submittals.

F. This contractor shall assume total responsibility for coordinating all inter-building wiring, any common carrier provided network equipment, and/or The Owner provided equipment as it relates to the operation of these systems.

1.3 SCOPE OF WORK

A. The contractor shall furnish all labor, equipment, materials, cabling, and the performance of all testing, commissioning, and certification in connection with the installation of a complete premises TCP/IP-based communications network structured cabling system and specified audio/visual systems in accordance with all requirements of the project drawings and/or as herein specified.

1. Provide and install all equipment described herein, including, but not limited to all, jacks/outlets, Category-6 cabling, fiber optic cabling, coaxial cabling, patch panels, distribution hardware, and patch cables as well as all conduits, outlet boxes and appurtenances necessary to provide complete and fully operating network communications structured cabling system.
2. Provide and install all equipment described herein, including, but not limited to all, video displays, projectors, video signal encoders, audio equipment and video processing equipment.

B. Communications Systems Design Requirements:

1. Provide a complete operational communications network infrastructure including but not limited to all cabling, jacks, cabling distribution and termination components as indicated on the contract drawings and as herein specified.

a. All horizontal network connections shall utilize copper cabling and hardware for distribution to all control equipment as indicated on the contract drawings. All horizontal cabling shall be bundled and routed through the facility on “J” hooks

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sized to support the network cabling requirements and shall terminate on Category-6 patch panels in the communications equipment enclosures.

1) NOTE: Cables shall not be cinched too tightly; cable ties at patch panel locations shall be hook-and-loop (VELCRO) type tie-wraps only. Plastic wire ties shall not be accepted on any cabling.

b. All communications cabling shall be terminated at both ends of the permanent link at all equipment locations, fiber optic, coaxial and patch panels.

c. The Contractor is responsible for the installation of the entire network communications infrastructure: including all workmanship, standards of quality, adherence to the contract documents, certification testing, as-built documentation, labeling, and final warranty in relationship to the performance and installation of the structured cabling systems in accordance with the contract drawings and/or as herein specified.

C. Backbone Performance Requirements:

1. The intended function of the communications network is to transmit data communications signals from a central location to several individual data drop locations. Upon completion of the work in accordance with the contract documents, the system shall be capable of transmitting data signals at a rate of 1000 Mbps minimum over Category-6 cable and a minimum of 10Gbps over single-mode fiber optic cables based upon the transmitting distance, laser attenuation and number of links.

a. Multimode OM4 50/125 micron (nominal) optical fiber cable.

b. Single-mode OS2 8.3/125 micron (nominal) optical fiber cable shall be capable of transmitting signals at both 1310 and 1550 nm capable of providing a nominal 5km @ 1GBPS @1000 Base LX and nominal 10km @ 10GBPS @10GBASE-LX4 transmission rates.

c. All fiber optic cable shall be terminated on LC-type connectors and ports.

2. The Contractor must certify in writing that the structured cabling system(s) are installed in accordance to the project documents, the referenced standards as well as all manufacturer requirements.

3. In addition, the contractor shall provide in writing all extended manufacturers' warranties for matching compatibility of the structured cabling system as well as all as-built drawings and field test reports for both the fiber and copper cabling systems before The Owner and the Design Professional will accept the installation.

1.4 SUBMITTALS

A. Refer to Specification Section 27 05 00 for additional information.

1.5 RECORD DOCUMENTS

A. Provide Owner with complete set of record drawings in accordance with the requirements of Section 27 05 00.

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PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturers listed as acceptable or equal shall not negate the contractor's responsibility for providing all systems in accordance with all functions and performance requirements of the Contract Documents.

B. Where manufacturer and/or model numbers reference specific system components in this specification, it is to establish the performance requirements and quality of the systems and components only.

1. It is in no way an inference that the referenced model numbers are the manufacturer's current product and are the only acceptable components for this project unless specifically referenced as "no substitutions."
2. Contractor shall provide the manufacturers' most current product that shall meet and/or exceed the specified performance and features of all data, and telecommunications equipment and/or systems.
3. Equivalent UL- listed equipment may be substituted for the approved manufacturers in accordance with all requirements of Division 01 specification section titled "Substitutions" and/or General Conditions to the Construction Contract and where approved equal is referenced in the specific specification section.

    a. Where systems and/or components are referenced as "no substitutions," the specific system and/or components shall be provided.
    b. All substitutions shall comply with all requirements as specified in related specification sections and all system performance standards shall be maintained.
    c. The contractor shall stipulate at the time of submission of bid the following information impacted by such a substitution.

        1) Any and all extensions in time impacted by the substitution.
        2) Any changes to the architectural or structural elements to the project.
        3) Differences in operation and/or performance from intended system criteria.

    d. Failure to provide the required substitution information shall result in, without consideration, the immediate rejection of the substituted equipment and/or systems.

C. Unless specified otherwise, the equipment furnished shall fall into six classes, and with the exception of Class 6, all of the material within a single class shall be the standard product of one manufacturer. Exceptions are noted as "Class Exempt." The six classes are as follows:

1. CLASS ONE-A (1A): Category-6 and Category-3 UTP, and Category-6 F/UTP copper cables (both horizontal and backbone), Category-6 patch cords, blocking kits, interconnection devices, connectors, wiring blocks, patch panels, and telecommunications outlets. Refer to applicable specification paragraphs for acceptable product manufacturers.

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a. Note: All material covered in “Class One-A” shall conform to all manufacturers’ cable/component matching connectivity requirements for the connection of all communications outlets, patch panels and cabling appurtenances provided as part of this project.
b. Other cabling systems meeting the listed performance and warranty requirements will be considered following compliance with all substitution requirements in accordance with Division 1 specification section titled “Substitutions.”

2. CLASS ONE-B (1B): Fiber Optic Cable (both horizontal and backbone), fiber optic jumpers, interconnection devices, connectors, wiring blocks, patch panels, and telecommunications outlets. Refer to applicable specification paragraphs for acceptable product manufacturers.

a. Note: All material covered in “Class One-B” shall conform to all manufacturers’ cable/component matching connectivity requirements for the connection of all communications outlets, patch panels and cabling appurtenances provided as part of this project.
b. Other cabling systems meeting the listed performance and warranty requirements will be considered following compliance with all substitution requirements in accordance with Division 1 specification section titled “Substitutions.”

3. CLASS TWO: Inner-duct systems. All material covered in “Class Two” shall be equal in quality and performance to that manufactured by Carlon, Eastern Wire+Conduit, Endot or approved equal.
4. CLASS THREE: Equipment racks, Wire Management Systems and Cable Trays. All material covered in “Class Three” shall be equal in quality and performance to that manufactured by Eaton (Formerly Cooper) B-Line, Chatsworth Products Inc., Legrand or approved equal.
5. CLASS FOUR: Communications Equipment Cabinets and Wire Management Panels.
6. CLASS FIVE: Velcro wire ties/cable wraps, storage rings, labels, "D" rings (metal only), nuts, bolts, screws, and other miscellaneous and hardware.
7. CLASS SIX: Active network systems/Equipment/Hardware

D. All equipment and peripheral devices shall be the standard product of a single manufacturer and shall display the manufacturer's name on each component.

2.2 COMMUNICATIONS NETWORK EQUIPMENT AND COMPONENTS

A. Data Communications Outlets (Category 6)

1. Data Jacks/Faceplates: 4 pair, TIA/EIA-568B pinning, Category-6 compliant.
2. Modular Outlet Jacks & Faceplates: Standard 8-position, RJ-45 style, un-keyed, designed for 4-pair, 100 ohm balanced unshielded twisted pair (UTP) cable, 26-22 AWG solid or stranded conductors.
3. Acceptable manufacturers for this project shall include **Hubbell, Ortronics, Panduit, Systimax.**
4. Accessories: Category-6 Jacks or approved equal include a translucent stuffer cap for wire retention and to permit visual inspection. Jacks shall have attached wiring instruction labels to permit either T568A or T568B wiring configurations.

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a. Modular Mounting Plates:

1) All mounting plates shall be supplied with mounting screws, clear screw covers and paper labels, and color matched screw covers. Office White – flush mounted with screws. Coordinate final color selection with architect.

B. Equipment Cabinets/Patch Panels/Appurtenances

1. Approved Manufacturers:

a. Hubbell
b. Eaton/B-Line
c. Panduit
d. Or approved equal

2. Provide wall-mounted communications equipment enclosures where indicated for all locations as indicated on the contract drawings. All wall-mounted enclosures shall meet the following requirements:

a. The enclosure shall be a UL listed; EIA compliant 19" horizontal distribution rack.
b. Minimum (26) EIA standard 19" rack units (RU)
c. 30" minimum usable equipment mounting depth
d. Front mesh door with lock
e. Locking swing-open center section for front and rear access
f. Adjustable rack rail
g. Integrated cable management
h. Electrical knock-outs for conduits on rear section/pan
i. UPS sized for all equipment with floor-standing or rack-mounted options.
j. Horizontal Power Distribution Unit (PDU)
k. Position and install rack so as to permit full swing of rack away from wall without obstruction.

3. Provide floor-mounted communications open frame equipment racks where indicated for all locations as indicated on the contract drawings. All racks shall meet the following requirements:

a. The rack shall be a UL listed; EIA compliant 19" horizontal distribution black in color.
b. 2-post with top plates and bottom plates for use with ½" anchoring hardware consisting of drop-in anchors, hex head bolts and fender washers on all mounting holes.
c. Double-sided vertical wire managers on both sides as indicated on the contract drawings.
d. Rack-mounted UPS sized for all equipment.
e. Vertical Power Distribution Unit (PDU)
f. Grounding busbar

4. Provide Fiber Optic Patch Panels (FOPP's) in sufficient quantities to support all fiber terminations as indicated on the contract drawings:

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a. IDF: Corning CCH-01U; MDF: Corning CCH-04U (or equals)
b. All housings: Provide with pigtailed cassettes, (6) duplex LC ports per cassette (12 strands per panel), Single-Mode (part number CCH-CS12-D9-P00RE or equal). Provide cassettes in sufficient quantities to terminate all incoming fiber optic strands.
c. Furnish housings with minimum 20% spare cassette slot capacity for addition of future panels.

5. Provide Modular Category 6 and Category 6A copper patch panels in sufficient quantities to support all Category 6 and 6A cabling terminations as indicated on the contract drawings:

a. Patch panels shall contain 110-block rear terminations for horizontal cabling and RJ-45 front connections for patch cords.
b. Patch Panels shall be 24-port TIA-568B wired Category 6 rated, Leviton # 69270-U24 or equal.

6. Patch Cables, Category 6, high performance: Leviton or equal (for back-of-house and amenity outlets only).

a. Patch cables shall be provided in standard lengths of three (03), five (05), seven (07), ten (10) or (15) feet.
b. Provide Two (2) patch cables for each populated patch panel port; one in the communications room, and one in the work area/space.

1) Patch cables in the communications room shall be of minimum length to permit installation without stress or strain at connection points to equipment, to permit relocation of cable to a different port on the same device, and to permit neat and workmanlike cable routing through cable management devices.
2) Patch cables in the work area/workspace shall be (15) feet in length.

c. All patch cables shall be EIA/TIA-568B compliant and meet all product matching criteria.
d. All patch cables shall be provided with jacket colors as specified elsewhere in this section.
e. All Category 6 Patch cords must be provided by the same manufacturer as part of a certified structured cabling system and shall be color coordinated in accordance with cable and jack color coding requirements.

7. Network equipment cabinet wire management: Provide wire management devices in network equipment cabinets as shown on the drawings and described in these specifications:

a. 1 Rack Unit (RU) Horizontal Wire Manager:
b. 2 Rack Unit (RU) Horizontal Wire Manager:
c. Provide hook-and-loop (Velcro) tie-wraps as required for neat and tidy rear cable management.

C. Category 6 Cable – Data Network Communications

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1. Category 6 Cable shall be "CAT6" cable tested to a minimum of 250Mhz, plenum-rated (CMP):

1. Provide fiber cabling in accordance with the requirements of all related specification sections, at the minimum 12-strand single-mode cable unless otherwise indicated by the contract drawings.

    a. Premise Distribution Interlocking-Armored plenum.

2. Acceptable manufacturers shall include Corning, Commscope or Berk-Tek.
3. Fiber Optic Cable Terminations

    a. All fiber optic cable shall be spliced on to splice-on connectors in the equipment racks.
    b. All splices shall be fusion type. Mechanical splices shall not be acceptable.
    c. All fiber optic connectors and patch panel ports shall be duplex SC/APC type.

D. Coaxial Cable (MATV/CATV Distribution)

1. Use RG-6/U cable for horizontal cable distribution drops to TV drop locations or as recommended by manufacturer.
2. Use RG-11/U cable for drops to TV locations or as recommended by manufacturer.
3. All coaxial cabling must be UL Listed, NEC type CL2 or CATV, Tri Shield, 75-Ohm cable installed in dedicated conduits.
4. Terminate all coaxial cable on coax patch panels in the equipment cabinet. At TV locations, terminate coaxial cable on single-gang wall pates with F-type connectors as shown on the contract drawings.

2.3 EQUIPMENT POWER DISTRIBUTION

A. Uninterruptable Power Supply (UPS)

1. Provide minimum 6kVA UPS at the bottom of each rack/cabinet, unless otherwise specified.
2. UPS shall be high density, double-conversion on-line power protection with scalable runtime. Runtime shall be minimum 30 minutes at full load.
3. UPS shall include web-based network management card with SNMP.
4. Provide all mounting hardware and cables.
5. Include floor-standing and rack-mounted options.

B. Rack Mounted Power Distribution Unit (PDU)

1. Provide rack mounted power distribution switch with surge protection for the distribution of all UPS connected power for each rack. The unit shall consist of a minimum of 12 AC power outlets, dual fed A/B circuiting, rated at 15 amps each and shall be equipped with integral surge protection circuitry (with bypass switch) capable of auto-resetting over-voltage and under-voltage protection.
2. The unit shall include a front mounted power switch (with guard) which shall control all 12 outlets. The four front mounted power outlets shall be spaced as transformer convenience outlets. The overall unit shall be single-height rack mountable chassis (1U)

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with three front panel indicator lights: (Power, Ground OK and Unsafe Voltage) and shall include front panel circuit breaker for protect or disconnect circuitry and dual 10-foot power cords for electrical power connectivity. The rear panel grounding lug shall be provided.

3. In addition to the above requirement the power distribution unit shall meet the following minimum requirements:

    a. Integral Surge Protection Circuitry (with by-pass switch): Yes
    b. Dual A/B Incoming Power Circuiting
    c. Protect or Disconnect Circuitry: Yes
    d. Thermal Fusing: Yes
    e. Catastrophic Surge Circuit: Yes
    f. Over/Under voltage Protection: Yes
    g. Overvoltage Shutoff Gate: 144V ±11V
    h. Under voltage Shutoff Gate: 84V ±6V
    i. Single Pulse Energy Dissipation: 1350 Joules
    j. Peak Impulse Current: 32,000A
    k. EMI/RFI Noise Filtration: 50db (99.7%)
    l. Line Voltage: 120VAC, 50/60Hz
    m. Initial Clamping Level: 200V Peak, 141 Rms
    n. UL 1449 Rating: 500V L-N, 500V L-G, 400V N-G
    o. Protection Modes: L-N, L-G, N-G
    p. Maximum Current Rating: 15A (1800W)
    q. Response Time: 1-5 Nanoseconds
    r. Plug Configuration: Straight
    s. Number of Outlets: 12 (4 front, 8 rear)
    t. Switched Outlets: All

PART 3 – EXECUTION

3.1 EQUIPMENT PROTECTION

A. Comply with all requirements of Specification Section 270500.

1. Examine all physical and environmental conditions, equipment and device locations, auxiliary system connectivity requirements impacting the installation of all network systems and report any unsatisfactory conditions in writing to The Owner and the Design Professional.

3.2 WORK PERFORMANCE

A. In addition to all requirements as specified by Specification Section 270500 the network communications systems shall also be provided in accordance with the following requirements:

1. Prior to the final commissioning and\or programming of any network communications components, the Contractor shall provide a review with The Owner and the Design Professional addressing all network integrations, programming, and related operational connectivity.

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a. Failure to provide this review and get final sign-off prior to programming shall result in any costs related to changes requested by The Owner and the Design Professional as not being charged to the project.

3.3 EQUIPMENT/CABLE INSTALLATION AND REQUIREMENTS

A. In addition to all requirements as specified by Specification Section 270500 the network communications systems shall also be provided in accordance with the following requirements:

1. All system cabling shall be of the type, size and specification as required by all contract documents as well as stipulated by all codes and standards as specified by Specification Section 270500.
2. All network communications cabling shall be installed in accordance with the requirements of Specification Section 270500. All network cabling bundles shall not contain any AC carrying conductors or non-associated network communications cables within the cable raceways/conduits or cable bundles.

a. In addition, all structured cabling associated with the installation of any network communications system shall comply with all requirements of TIA standards for the proper installation, termination and testing of all fiber optic and UTP cabling.
b. Contractor shall provide all equipment, components, devices, hardware, equipment racks\cabinets, patch panels and all appurtenances necessary to provide fully operational network communications systems utilizing a UTP cabling topography. Coordinate all structured cabling with all trades and contractors prior to shop drawing submission.

3.4 ELECTRICAL POWER DISTRIBUTION

A. Comply with all requirements of Specification Section 270500.

1. All system power supplies serving system components or devices on the exterior of the facility shall be provided with the appropriate transient surge and suppression protection on both the line side as well as the load side. Refer to specification section 27 05 00 for additional requirements.
2. Installation of all equipment and devices that pertain to other work in the contract shall be closely coordinated with the appropriate trade contractors.

3.5 TRANSIENT VOLTAGE SUPPRESSION

A. Comply with all requirements of Specification Section 270500.

3.6 GROUNDING AND BONDING

A. Comply with all requirements of Specification Section 270500.

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3.7 EQUIPMENT IDENTIFICATION

A. Comply with all requirements of Specification Section 270500.

3.8 MAINTENANCE & SERVICE

A. Comply with all requirements of Specification Section 270500.

3.9 WARRANTY

A. Comply with all requirements of Specification Section 270500

B. Provide all manufacturers extended cable warranties based on matching wire to component compatibility requirements. All cable warranties shall be in effect for a period of not less than 20 years.

C. The warranty must include the following statements regarding the cabling system:

1. "That all communications networks have been certified and will support and conform to ANSI/TIA-568-C specifications covering any current or future application which supports transmission over a properly constructed and horizontal cabling system premises network which meets the channel and/or basic link performance as described in ANSI/TIA-568-C."
2. “That all communications networks are free from defects in material or faulty workmanship."

3.10 FIELD SERVICES

A. Comply with all requirements of Specification Section 270500

3.11 TRAINING

A. Comply with all requirements of Specification Section 270500.

B. Documentation:

1. Contractor shall provide documentation to include all test results and as-built drawings, test results shall be computer generated and shall include all trace reports indicating each pair tested in accordance with all requirements of Specification Section 270500.

a. One Hard Copy shall also be provided to The Owner and the Design Professional. Software for viewing the test results shall also be provided in the soft copy package.

C. Final Acceptance

1. Acceptance of all network communications systems, by The Owner and the Design Professional, shall be based on the results of testing, functionality, and the receipt of docu-

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mentation. The testing of all UTP cabling, fiber segments and all security and data network cables must meet the criteria established in the Specification Sections 270500.

2. The Contractor must demonstrate to The Owner and the Design Professional that 1000 Mbps data signals can be successfully transmitted, bi-directionally, from the communications room patch panels to and from a minimum of 10% of individual data drops on each floor, witness tested by The Owner and the Design Professional. The number of data drop locations to be tested shall be determined by The Owner and the Design Professional. With regard to documentation, all required documentation shall be submitted to The Owner and the Design Professional.

D. As-Built Documentation:

1. Contractor shall provide clean copies of the technology drawings depicting all as-built conditions for all data drop locations, cable routing and identification, patch panel, data switch port terminations, component layouts and all information as required by Division 01 specification section.

END OF SECTION 27 11 00

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SECTION 27 41 00

AUDIOVISUAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Division 1 Specifications, General and Supplemental Requirements apply to this section with additions and modifications specified herein.

B. Instructions to Bidders, Bidding Forms, Forms of Agreement between Owner and Contractor, Contract Award Date, Starting and Completion Dates, Conditions of the Contract, Insurance Requirements, and other Owner Requirements will be furnished separately by the Owner. These documents, as well as any addenda issued, shall form a part of these Specifications, and this Contractor shall consult them in detail for instructions pertaining to his work.

C. Each trade contractor shall receive all drawings and specification sections issued as part of the overall bid package. All contractors are to receive, review, and coordinate all of their work as shown or referenced on the other trade documents. All work shown or referenced on the other trade documents shall be included as part of the overall project scope for that particular discipline and trade.

D. All other Division 27 Specifications.

1.2 SUMMARY

A. These specifications and accompanying drawings are intended to cover the furnishing of all labor, material, and equipment and superintendence of the Audiovisual (AV) and Paging Systems.

B. It is the intent and purpose of this specification and accompanying drawings to cover and include each item, all materials, machinery, apparatus, and labor necessary to properly install, equip, adjust, and put into perfect operation the respective portions of the installations specified and to so interconnect the various items or sections of the work as to form a complete and properly operating whole.

C. Any equipment, apparatus, machinery, material, and small items not mentioned in detail, and labor not hereinafter specifically mentioned, which may be found necessary to complete or perfect any portion of installation in a substantial manner, and in compliance with the requirements stated, implied or intended in these specifications shall be furnished without extra cost. This shall include all materials, devices, or methods peculiar to the machinery, equipment, apparatus, or systems furnished and installed as part of the AV Systems work.

D. Drawings and this Section outline the performance requirements of the AV system. The Drawings are diagrammatic in nature and are meant to convey the performance intent of the system. Contractor shall develop a solution for each portion of the AV system and submit detailed shop drawings and product datasheets to indicate the proposed approach.

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E. The following major system components may be specified under this section:

1. Signal Switching Transport
2. Controllers and Control Interfaces
3. IP encoders, decoders and network hardware to support AV systems.
4. Signal Processing Systems
5. Signal Recording and Storage
6. Cabling and Connectors
7. Racks and Connection Panels
8. Displays
9. Projectors and Projection Screens
10. Collaboration Systems and Appliances
11. Collaboration and Event Cameras
12. Wireless Presentation System
13. Wired and Wireless microphone system
14. Loudspeakers

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. No products have been identified to be furnished but not installed.

1.4 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. Products installed but not furnished includes all Owner Furnished Equipment (OFE) items which shall be configured and installed as part of a complete and working system as identified in the section summary.

B. Refer to the 274100 Appendix A – Audiovisual Systems Equipment list for equipment identified as OFE.

C. All Owner Furnished Equipment, with the exception of Room PCs imaged with Owner's standard user desktop profile, shall be maintained as part of the labor portion of the system warrantee.

1. Contractor shall assist in initial troubleshooting of Owner Furnished Equipment and if necessary, manage the equipment replacement process within the existing manufacturer warrantee period.

D. New OFE Items

1. Contractor shall take receipt of any new equipment procured by the Owner for this project, including Room PCs, Mini PCs, CATV Tuners, etc. as indicated in the Audiovisual Systems Equipment list.

a. If necessary for shop fabrication and testing, Contractor shall take receipt of equipment at Contractor's system staging location and transport the complete AV assemblies to the project site.

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1.5 WORK NOT INCLUDED IN SCOPE

A. Contractor shall coordinate with associated trades providing all work outside of this scope which may be necessary for a complete and working system.

B. Work not included in scope includes:

1. AV empty conduit, junction boxes, floor boxes, poke-thrus and other pathways for AV low voltage cabling unless otherwise specified in this section.
2. Display in-wall boxes.
3. Power receptacles supporting AV equipment.
4. AV furniture including tables, lecterns, and credenzas.
5. Table hatches or table connectivity enclosures

    a. Contractor to coordinate and provide all hatch and enclosure faceplates, connectors, and cabling.

6. Architectural or event lighting control interfaces

    a. Contractor to coordinate and provide all cabling between AV and lighting controllers.

7. Owner network horizontal cabling and ports between an AV device and the Owner's IDF/MDF/Network rack.

    a. Contractor to coordinate and provide all patch cabling between Owner network drop termination points and AV devices including.

        1) Includes patch cabling run in glass front extrusions for use with room scheduling devices.

    b. Contractor to coordinate and provide all network drops between AV devices or between an AV device and contractor provided network switch.

1.6 PRICE PROCEDURES

A. Unit Pricing

1. Contractor shall provide unit and system pricing as part of their bid submission and maintain unit pricing throughout the contract term.

1.7 LAWS, REGULATIONS AND CODES:

A. Perform all work in strict compliance with all laws, regulations, and/or codes applying, including all Federal, State, and local codes and any other authority having jurisdiction. Wherever drawings or specifications conflict with such regulations they shall be made to conform, and approval of the Design Professional obtained on such changes as may be involved.

B. All electrical and telecommunications work shall comply with the requirements of the National Electrical Code, latest accepted revision.

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1.8 PERMITS, FEES, AND CERTIFICATES OF APPROVAL:

A. Unless stated otherwise in General Conditions or Division 1, obtain, and pay for all permits, fees, and licenses required, including those of utilities and Agencies. Provide copies to Design Professional in the quantity requested. "Fees" shall include connection charges construction costs, and other such charges by utility companies or service providers. Ascertain such charges during bidding period and include bid price.

1.9 REFERENCES

A. The publications list below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

B. Specific reference in specifications to codes, rules, regulations, standards, manufacturer's instructions, or requirements of regulatory agencies shall mean the latest printed edition of each in effect at the date of contract unless the document is shown dated.

C. Conflicts:

1. Between referenced requirements: Comply with the one establishing the more stringent requirements.
2. Between referenced requirements and contract documents: Comply with the one establishing the more stringent requirements.

D. References:

1. General: The system shall comply with all applicable codes, ordinances and standards as interpreted and enforced by the local authority having jurisdiction.
2. Avixa (Audiovisual and Integrated Experience Association, previously InfoComm) standards including:

    a. Display Image Size for 2D Content in Audiovisual Systems
    b. Cable Labeling for Audiovisual Systems
    c. Audio Coverage Uniformity in Listener Areas
    d. Standard Guide for Audiovisual Systems Design and Coordination Processes
    e. Projected Image System Contrast Ratio
    f. Audiovisual Systems Energy Management
    g. AV Systems Performance Verification
    h. Audio, Video and Control Architectural Drawing Symbols Standard
    i. Electronic Symbol Files - Audio, Video and Control Architectural Drawing Symbols

3. American Society for Testing and Materials (ASTM)
4. ANSI standards including:

    a. ANSI/TIA/EIA-568-B.1 Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements
    b. ANSI/TIA/EIA-568-B.3 Commercial Building Telecommunications Cabling Standard, Part 3: Optical Fiber Cabling Components Standard

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c. ANSI/TIA/EIA-569-B Commercial Building Standard for Telecommunications Pathways and Spaces
d. ANSI/TIA/EIA-606-A The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
e. J-STD-607-A Commercial Building Grounding and Bonding Requirements for Telecommunications
f. ANSI/TIA/EIA-526-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
g. ANSI/TIA/EIA-526-14A Measurement of Optical Power Loss of Installed Multimode Fiber Cable Plant

5. BICSI -- Telecommunications Distribution Methods Manual
6. BICSI -- Cabling Installation Manual
7. Underwriters Laboratories Listed, UL Certified
8. National Electrical Code Articles 770 and 800.
9. NFPA 780 - 2005 or newer.
10. RUS Standards (formerly REA)
11. Local State Uniform Fire Prevention and Building Code.
12. Local State Department of Labor Rules and Regulations
13. Local State Department of Health
14. Code of Federal Regulations (CFR) [Telecommunications] Title 47 Part 90
15. Code of Federal Regulations (CFR) [Telecommunications] Title 47 Part 15

1.10 DEFINITIONS

A. The term "Furnish" shall mean to obtain and supply to the job site. The term "Install" shall generally mean to fix in position and connect for use. Where language indicates that one party or trade is to "install", and another is to "connect", the term "install" shall mean only to fix in position, and "connect" shall mean to make electrical connections. The term "Provide" shall mean to furnish and install.

B. ANSI – American National Standards Institute

C. AV – Audio / Visual, audiovisual, audio visual

D. Avixa - Audiovisual and Integrated Experience Association, formerly InfoComm

E. HTML – HyperText Markup Language

F. IP – Internet Protocol

G. ISO – International Organization for Standardization

H. NEC – National Electrical Code

I. NEMA – National Electrical Manufacturing Association

J. SNMP – Simple Network Management Protocol

K. TCP – Transmission Control Protocol

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L. TIA – Telecommunications Industry Association

M. UL – Underwriters Laboratories

N. VLAN – Virtual Local Area Network

O. VoIP – Voice over Internet Protocol

P. VPN – Virtual Private Network

1.11 RECORD DRAWINGS:

A. During construction keep an accurate record of all deviations of the work as shown on the drawings and that which is actually installed.

B. Secure from the Design Professional a complete set of prints of the AV drawings and note changes thereon. Make a complete record in a neat and accurate manner, of all changes and revisions to original design which exist in completed work, in the file format originally received.

C. The cost of furnishing above drawing files and preparing these record drawings shall be borne by the Contractor. When all revisions showing the work as finally installed are made, the corrected prints and drawings files shall be submitted for review and approval by the Design Professional.

D. Record drawings shall be delivered to Owner within 30 days after acceptance of completed project by Owner.

1.12 OPERATING INSTRUCTIONS:

A. Provide to the Owner three bound copies of complete written instruction on the operation, care and maintenance of each piece of equipment and the installation as a whole. Include frequency of inspection, cleaning and adjusting and other attention as may be required in accordance with manufacturer's instructions. Material shall be manufacturer's brochures, catalog cuts, parts lists, wiring diagrams, etc. Also supply Owner with three complete sets of approved shop drawings.

B. Furnish qualified personnel to instruct the Owner's personnel in the maintenance and operation of all equipment and systems. Instructing personnel shall remain on the job continuously during working hours until such instruction is complete, but not less than 16 hours.

1.13 PERFORMANCE REQUIREMENTS

A. Provide a complete, fully functional installation of the AV and Paging System and associated components including:

1. Engineering and installation services aligning to the published project schedule.
2. Coordination with the Owner, Architect, Design Professionals, General Contractor and all associated trades.
3. Creation, submission, and revision to the point of receiving approval of an AV Systems Submittals package.

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4. Equipment procurement.
5. Equipment delivery to the site and removal of all trash.
6. Provide all installation tools and materials necessary to complete all equipment installation tasks including ladders, scaffolding and lifts.
7. Equipment installation.
8. Systems setup, configuration, and commissioning.
9. Systems demonstration to Owner and Design Professional.
10. Remediation of any systems identified by Owner and Design Professional as not meeting published equipment specifications or the requirements as set out in this scope of work.
11. As-built documentation.
12. End User Training.
13. AV Systems Warrantee.

B. Provide all equipment accessories, manuals, mounting hardware, remotes and other ancillary pieces furnished by the manufacturer but not required for installation.

C. Provide all AV and paging low-voltage cabling, connectors, connector plates, patch bays and patch cables.

1. Confirm cable types and verify required length of all installed and portable premanufactured cables and assemblies prior to order.

D. Terminate and test all AV and paging low-voltage field connections.

1. Provide all connectorized plates, connectors, cable labels and plate labels.
2. Confirm finish of all plates and labels with Design Professionals.

E. Install and configure Owner Furnished Equipment.

F. Confirm color selection of all exposed AV equipment with Owner prior to order.

G. Confirm required openings, recesses and mounting locations of all AV equipment to meet manufacturer requirements. Verify onsite prior to completion of wall framing and electrical rough-in.

H. Contractor to include manufacturer onsite oversight labor including commissioning services and end user training for any systems which Contractor does not have staff with relevant manufacturer training and any available manufacturer certifications.

I. Provision all video conferencing, wireless presentation and other collaboration hardware endpoints with Owner's network and collaboration system registration information.

J. Coordinate AV equipment blocking requirements with the General Contractor prior to installing AV equipment.

1. All wall or ceiling mounted equipment to be provided with hardware sized for a 5:1 safe working load limit.
2. All ceiling mounted equipment to be provided with a safety cable or redundant support system attached to building structure and sized for the equipment by the equipment manufacturer.

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K. Install all AV and paging rack hardware including rack bases and wall supports.

1. Confirm that all AV rack locations will allow proper clearances.
2. Coordinate with the General Contractor location of all AV rack power receptacles, data jacks, CATV jacks and empty AV low voltage junction boxes.
3. Confirm sufficient heat exhaust and cooling systems have been provided to meet systems demand loads.
4. Request of the General Contractor a normally-closed fire alarm mute contact for all event systems as identified in the Audiovisual Drawings.
5. Provide rack hardware, cable management hardware and rack accessories as necessary to meet rack and equipment manufacturer recommended configurations.

L. Provide all necessary copper and fiber patch cables for making all device interconnections. Patch cable type and color shall be coordinated with the structured cabling package to match project standards.

M. Provide an AV equipment network coordination submittal for Owner completion. Configure all AV equipment with the confirmed network settings and test operation on the Owner network.

N. Loudspeakers

1. Coordinate location of all wall and ceiling speaker systems including location of low voltage and power infrastructure.
2. Review all ceiling speaker mounting conditions and provide ceiling speakers with a tile bridge or other relevant manufacturer support system.
3. Where indicated in the specification, paint all exposed speaker grills with a custom color as confirmed by Owner.

O. Furniture

1. Coordinate with furniture providers all AV equipment installation requirements including cutout sizes, connector/plate openings, wiring openings, raceways, methods of affixing cables and equipment.

    a. All equipment and cabling shall be installed in a neat and professional manner with the intention of limiting visibility of supporting hardware and cabling.
    b. All table cabling shall be secured to the table or hidden in a plinth, cloth wrap or articulating cable manager.

2. For all technical furniture provided under this scope of work, coordinate equipment layouts, and finishes with Owner and Design Professional prior to ordering.

P. Wireless Systems

1. Coordinate wireless frequency selection based on a site survey and relevant government agency requirements. Address any wireless channel conflicts prior to equipment ordering.

    a. For meeting or event space wireless microphone and in-ear monitor systems, provide the Owner with a system capable of adjusting wireless frequency as necessary to maintain reliable system operation in the installed environment.

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2. Coordinate placement of wireless antennas and provide antenna splitting, combining and amplification as necessary to operate within manufacturer required signal strength ranges.

Q. Control Systems

1. Coordinate with the General Contractor the location of all external system interfaces including lighting, shades, occupancy, BMS as required.

   a. Provide cabling between AV controllers and external system interfaces.

2. Provide custom AV control system code development as necessary to operate all AV equipment user controls per specification.

   a. Manage a control interface confirmation process with Owner and Design Professional as outlined in the AV submittal requirements.

3. Configure all digital signal processors, content management systems, scheduling systems and other processor-based platforms to optimize to the spaces and systems being served.

1.14 QUALITY ASSURANCE

A. Comply with the requirements of the following codes and/or standards:

1. ANSI.
2. ANSI.
3. UL.
4. NEMA.
5. NFPA.
6. NEC.
7. IBC 2009.
8. BICSI.
9. ANSI/TIA 568-D Series.
10. ANSI/TIA 569-E.
11. ANSI/TIA 606-C.
12. ANSI/TIA 607-D.

B. All packaged equipment shall be independently Third Party labeled as a system for its intended use by a Nationally Recognized Testing Laboratory (NRTL) in accordance with the OSHA Federal Regulations 29CFR1910.303 and .399, as well as NFPA Pamphlet #70 and National Electric Code (NEC), Article 90-7.

C. The contractor shall be certified by the manufacturer of the products, adhere to the engineering, installation and testing procedures, and utilize the authorized manufacturer components and distribution channels in provisioning this Project.

D. All members of the installation team shall be certified by the manufacturer as having completed the necessary training to complete their part of the installation. Resumes of the entire team shall be provided along with documentation of completed training courses. Submit resume and copy of technician's license including:

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1. A Technical resume of the Contractor's Project Manager and Field Supervisor documenting a minimum of five (5) years of experience installing similar size projects.
2. Matching documentation for any Sub-Contractor who will assist the Contractor in performance of this work.

E. All hardware, software, firmware, and/or operating system requirements given are the minimum requirements. The Contractor's product shall meet or exceed these requirements. The product selected shall meet the operational, functional, and performance requirements specified herein. Additionally, due to the rapid advancement and antiquation of technology related products, the supplied product shall be the "contemporary technical equivalent" of that specified. "Contemporary technical equivalent" shall be based on a comparison of technology at the time of publication of specification to the technology at the time of the first product submittal. Final product approval is at the sole discretion of the Owner.

F. Manufacturer: Where Contractor has the ability to select a preferred manufacturer for items not specifically covered in the Appendix A Audiovisual Systems Equipment list, the manufacturing company selected shall have a minimum of five years of experience in producing the products.

1.15 SUBMITTALS

A. Contractor must receive approval from the Owner or Design Professional of a submittal before procuring equipment or performing services related to the submittal.

B. All submittals shall be provided in electronic format.

1. Provide one full size paper submittal if requested by Owner.
2. Confirmation of the submittal schedule and submission format must be obtained by Owner prior to creating individual submissions.

C. Revised submittals shall include clouding or other method to indicate revisions since the prior submission.

D. Project Status Report

1. A project status report shall be sent to the Owner and Design Professional weekly starting within two weeks of award. The project status report shall be used as the basis for Contractor coordination meetings and shall include:

a. Team member contact information
b. Project overall schedule

1) Highlight changes to the schedule since last issuance.
2) Identify critical schedule items.
3) Identify opportunities to improve on the current schedule.

c. Action items from prior coordination meeting and status of each item
d. Installation schedule and status for each unique space or system in the project.
e. Outstanding Owner coordination items.
f. Outstanding Design Professional coordination items.
g. Change Order Status

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h. Submittal Approval Status

E. Within five business days of award, submit an installation schedule including major milestone dates for construction phasing based on overall project construction schedule (along with separate phases where applicable), system and device configuration, testing and training. Include the following milestones:

1. Separate milestones for each submittal.
2. Signage content and system configuration coordination session.
3. Required date for receipt of all OFE equipment per project phase or equipment type.
4. Required data for receipt of any Owner furnished signage content.
5. AV project manager onsite.
6. Delivery of all Furnished but not Installed equipment to site.
7. Cable pulls start and complete.
8. Mount and speaker installation start and complete
9. Equipment installation start and complete
10. Systems configuration and testing start and complete.
11. Systems ready for checkout and punch list
12. Owner training
13. As-built submission

F. Within 30 business days of award submit an AV infrastructure review memo confirming infrastructure shown on the AV, Architectural, Telecom, Mechanical and Electrical design packages meets AV equipment installation requirements or identifying specific adjustments necessary to support the specified AV equipment.

1. Verify AV conduit sizing and pathways.
2. Verify architectural recesses and ADA clearances.
3. Verify data drops to support AV network connectivity.
4. Verify AV power receptacles and multi-discipline shared services device requirements (in-wall boxes, floor boxes, poke-thrus.
5. Verify AV enclosure cooling/exhaust.
6. Verify ceiling device layouts and clearances, projector, and projection screen orientation.

G. Qualifications: The Contractor shall submit qualification data sheets for firms and persons as specified in the "Quality Assurance: section of this specification to demonstrate their capabilities and experience.

H. Submit proposed product data sheets: The Contractor shall submit catalogue cut-sheets that include manufacturer, trade name, and complete model number for each product specified or selected for use in the project.

1. Model number shall be highlighted to indicate exact selection per system type.
2. Product data sheets shall be organized with separate folders per system type with a master equipment list broken into three sections:

a. System types and quantities of systems
b. Equipment and equipment quantities per system type
c. Master project equipment list and quantities

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3. Confirm manufacturer master quote numbers and the accuracy of the master quotes against the specified equipment.

I. Submit shop drawings detailing proposed system architecture and interconnectivity.

1. All shop drawings sheets shall be sized to match the project architects drawing format.
2. Shop drawings shall include the following drawing information.

a. Scaled floorplans indicating the area of work and room types.
b. Enlarged plans indicating equipment locations, mounting requirements, clearances, infrastructure requirements, and cable routing.

1) Provide projector and projection screen throw distance calculations.
2) Provide display elevations and sections.
3) Identify any details which do not meet minimum ADA clearance requirements.
4) Identify equipment centerline coordinated with furniture and main display wall.

c. Device details indicating mounting requirements for each unique equipment type in the project.

1) All overhead equipment details must identify the safe working load and manufacturer provided safety hardware. Where a custom mounting detail is required using fabricated components or components provided by multiple manufacturers a structural detail, reviewed and stamped by a Structural Engineer license in the project state, must be provided.
2) Copies of manufacturer cut sheet details shall not be considered sufficiently coordinated.

d. Rack elevations and mounting details with clearances and infrastructure requirements
e. System flow diagrams with cable labels and corresponding cable schedule indicating wiring interconnections between all AV devices and Owner's network.
f. Wiring termination details.

1) Include cable labelling standards and materials.

g. Panel details showing all prefabricated and custom connector panels, connector types, labels and required backbox.
h. Technical Furniture details indicating the location, required openings and cable management of all AV equipment in furniture and millwork regardless of what scope the furniture is provided under.

J. Control Systems

1. Owner or Design Professional approval of all Control Systems submittals is required prior to installation. Failure to secure approval shall not be grounds for project schedule delay or Contractor change order.
2. Submit button panel layouts with labelling/engraving and sequence of operations.
3. Submit audio DSP configuration files.

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4. Submit an initial and up to two revised set of touch panel user interface submittals.

    a. Contractor shall lead a user interface review session with Owner and Design Professional prior to start of touch panel user interface design. Contractor shall provide up to three design samples in advance of the user interface session for Owner and Design Professional review.
    b. User interface layouts shall follow the best practices laid out in the InfoComm *Dashboard for Controls*
    c. The overall user interface design process shall reflect the current draft Avixa UX 701.01 *User Experience Design for AV* recommendations.
    d. User interfaces shall include the following basic features:

        1) Control of all local AV equipment addressable parameters required during the specified use cases.
        2) Call controls, transport controls, source selection, volume controls as appropriate.
        3) Standard controls formatted to match industry standard applications (knobs, sliders, buttons, interactive menus, etc.)
        4) A password protected advanced section allowing for control of individual device parameters (power, channel level controls, input selection, etc.)
        5) Utilize stock manufacturer pages and capabilities where possible. Custom scripting shall be avoided unless where required as part of this specification.

K. Network Coordination Submittal

1. Submit a detailed list of all network enabled AV devices detailing:

    a. MAC address
    b. IP Address (for Owner to complete)
    c. Subnet (for Owner to complete)
    d. Wired and Wireless VLans
    e. DHCP requirement
    f. Unique network requirements including firewall exceptions, port forwarding and Qos

2. Lead an AV network coordination session with the Owner and Design Professional to confirm overall project AV network requirements and set a schedule for completion and return of the Network Coordination Submittal by the Owner.

L. Owner Training Plan

1. Identify specific systems to be trained on and training durations.
2. Identify required project stakeholders.
3. Identify training status and provide training sign-off sheets.
4. Provide training materials and user one-page operations sheets for each system types.

M. Operations and Maintenance Manuals:

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1. This Section requires complete documentation of the AV System for the purpose of system operation and maintenance during and after the Warranty period. It is intended that the operation and maintenance manuals be exhaustive in the coverage of the system to the extent that they may be used as the sole guide to the troubleshooting, identification, and repair of defective parts. All documentation, as described here-in shall be submitted to the Owner for approval sixty (60) days prior to final submission.
2. Scope: These manuals shall include basic wiring diagrams, schematics, and functional details such that any component, wire, or piece of equipment in the system may be easily identified by going to the actual equipment and making reference to this manual. It is required that everything in the system be neatly labeled and easily identifiable. Every terminal, wire, component, or piece of equipment, and other such items shall have a number or letter designation. All of these identification characteristics shall be included in the maintenance and operation manuals.
3. The maintenance manual requirement of this Section is in addition to Shop Drawing requirements. Maintenance manuals and Drawing sets shall be compiled after system fabrication and testing and shall incorporate any changes made after Shop Drawing submittal. The maintenance manuals and drawing books shall be permanently bound in hard plastic covers.
4. Maintenance Manuals, Manufacturer's Literature: Provide manufacturer's standard literature, covering all equipment included in the system. The maintenance manuals shall contain specifications, adjustment procedures, circuit schematics, component location diagrams, and replacement parts identification. All references to equipment not supplied on this Project shall be crossed out.
5. System Administrator Documentation: This documentation shall provide complete information on the configuration, business rules, operation, maintenance, and trouble-shooting of the system.

N. Testing Plan

1. Submit a systems testing and verification plan for approval by Owner and Design Professional.
2. The approved Testing Plan shall be completed and provided to the Owner and Design Professional prior to commencement of Owner testing and punch list efforts.

O. As-Built Documentation

1. Submit an updated version of all submittals revised to match installed conditions.
2. Submit the native version of all drawing, control programming, digital signal processing and other systems configuration files.

P. Warranty

1. Within 30 business days of award, provide a summary of the systems warrantee including all optional services for final Owner confirmation.
2. At time of as-built documentation submission provide two physical copies of the hardware and software warranty certifying that the final as-built installation is fully warranted by the manufacturer.

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1.16 GENERAL WARRANTY

A. The system warranty shall commence on the date of Substantial Completion unless otherwise provided for in the Contract.

B. The system warranty shall be for an initial period of one year.

C. Hardware Warranty:

1. Contractor shall warrant that all components meet or exceed the specifications provided in the product data submittal.
2. The Contractor shall warrant that the proposed merchandise will conform to its description and any applicable specifications and shall be of good quality for the known purpose for which it is intended.
3. The warranty shall cover material and labor for the replacement or repair of defective products.
4. Regardless of manufacturer warranties expiring before the full system warranty period, Contractor shall be responsible for extending any manufacturer warranties for the full length of the system warranty.

D. Software Warranty:

1. The warranty shall allow for replacement or repair at the discretion of the Owner. All software necessary to compile, modify, and maintain software developed for this specification shall be included in this warranty.
2. The warranties shall include the price of all software upgrades during the warranty period. If a new version of the system software becomes available during the warranty period, it shall be upgraded as part of the warranty.

1.17 MAINTENANCE AND SUPPORT SERVICES

A. Description of Work: During the warranty period provide 24-hour, 7 days a week live monitoring of the system from the Contractor's operations center. Provide customer service for subscriber issues Monday – Friday, 9am – 5pm local time. Provide quarterly system inspections, checks and updates during the warranty and maintenance period.

B. Personnel: Service personnel shall be certified in the maintenance and repair of similar types of equipment and qualified to accomplish work promptly and satisfactorily. Service personnel shall hold a valid Airport security credential. The Owner or Owner's Designated Representative shall be advised in writing of the name of the designated service representative, and of any change in personnel.

C. Schedule of Work: The Contractor shall perform quarterly inspections of the installed system. Inspections shall be in accordance with manufacturer and Contractor recommendations. The adjustment and repair of the system shall include visual checks of installed equipment and inspection of system health logs and software. Recommended software updates shall be applied on the system at these pre-defined quarterly periods.

D. Scheduled Work: Scheduled work shall be performed during regular working hours, Monday through Friday, excluding holidays.

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E. Emergency Service: The Owner will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the complete system repair. The Owner shall be furnished with a telephone number where the service supervisor can be reached at all times. Service personnel shall be at site within 4 hours after receiving a request for service. The system shall be restored to proper operating condition within 8 hours after service personnel arrive onsite.

F. Records and Logs: The Contractor shall keep records and logs of each task, and shall organize cumulative records for each component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain all initial settings. Complete logs shall be kept and shall be available for inspection on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the system.

G. Work Requests: The Contractor shall separately record each service call request, as received. The form shall include the serial number identifying the component involved, its location, date and time the call was received, specific nature of trouble, names of service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the material to be used, the time and date work started, and the time and date of completion. The Contractor shall deliver a record of the work performed within 5 days after work is accomplished.

H. System Modifications: The Contractor shall make any recommendations for system modification in writing to the Owner. System modifications shall not be made without prior approval of the Owner. Any modifications made to the system shall be incorporated into the operation and maintenance manuals, and other documentation affected.

I. Spare Equipment:

1. Provide spare equipment where indicated in the 27 41 00 Appendix A.

1.18 SERVICE LEVEL AGREEMENT (SLA)

A. The Contractor shall provide with the bid a firm fixed pricing option(s) to provide continued warranty service and maintenance of the system for additional years two and three. The SLA shall mirror that of the warranty and maintenance requirements during the warranty period as outlined in the Warranty and Maintenance articles above.

1.19 DELIVERY, STORAGE, AND HANDLING

A. Contractor shall coordinate secure storage onsite with the General Contractor and is responsible for the safe delivery, storage and handling of all equipment covered in this scope of work through substantial completion of the work.

1.20 PROJECT CONDITIONS

A. Environmental Limitations: System components shall be equipped and rated for the environments where installed.

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B. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

C. Interior, Controlled Environment: System components shall be rated for continuous operation in ambient conditions of 2 to 40 deg C dry bulb and 20 to 90 percent relative humidity, noncondensing.

D. Interior, Uncontrolled Environment: System components installed in non-air-conditioned interior environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.

E. Verify that field measurements are as shown on Drawings; no media, fiber, or copper, shall be installed in lengths surpassing Standards based length requirements.

F. Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet Project conditions.

G. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required. Record actual routing on as-builts for all conduit larger than one inch.

1.21 PROJECT COORDINATION

A. Determine required separation between cable and other work.

B. Coordinate cable routing to avoid interference with other work disciplines.

C. Coordinate grounding and bonding with Section 270527 Contractor.

D. Coordinate use of fiber optic cabling infrastructure with Section 271310 Contractor.

E. Coordinate network configuration requirements with Section 272000 Contractor.

PART 2 - PRODUCTS

2.1 APPENDIX A – AUDIOVISUAL SYSTEMS EQUIPMENT LIST

A. Refer to the attached 27 41 00 Appendix A - Audiovisual Systems Equipment List for product information, alternates, and manufacturer quotes.

B. The Appendix A shall be used as the basis for Contractor pricing. A native excel version of the appendix shall be filled out by the Contractor and returned with the bid response.

C. Contractor shall verify any existing manufacturer quotes, including those listed in the Appendix A, match the project requirements.

1. Contractor shall be responsible for addressing any discrepancies between manufacturer quotes and project requirements.

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2.2 SUBSTITUTIONS

A. Contractor requests for substitutions shall be made in writing and shall include:

1. The equipment or process requested for substitution and a summary of the reason for substitution.
2. The requested equipment or process to substitute with and a feature comparison with the base scope of work.
3. Proposed cost and schedule impacts.

B. No substitution shall be allowed without written approval of the Owner or Design Professional.

C. Cost and schedule impacts will only be considered for approval in the event that the substitution is due to factors outside of the control of the Contractor.

PART 3 - EXECUTION

3.1 GENERAL

A. Contractor shall install all system components including furnished equipment, and appurtenances in accordance with the manufacturer's instructions, and shall furnish all cables, connectors, terminators, interconnections, services, and adjustments required for a complete and operable system.

B. Grounding shall be installed as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.

C. Contractor shall adhere to the following during installation of the system:

1. Underwriters Laboratories (UL) listing for restricted access installations in business and customer premises applications. This listing is required by the National Electric Code for customer premise installations.
2. Fire resistance requirements specified by Underwriters Laboratories in UL 1459, 2nd edition.

D. Where undefined by codes and standards, Contractor shall apply a safe working load of at least five (5) times the rated load to all fastenings and supports of system components.

E. The Contractor shall adhere to the installation schedule of the General Contractor and should attend all construction meetings scheduled by the General Contractor.

F. Contractor shall place materials only in those locations that have been previously approved. Any other locations shall be approved, in writing, by the Owner.

G. All wiring and cables shall be properly dressed and/or bundled with Velcro straps. Twisted wire, tape, rope, twine, phone wire and similar bits of debris usually available on site are not acceptable substitutes for proper securing hardware. All inter-rack cables and wiring must be properly routed, and where available, run in cable trays. Overhead cables must be easily removed or reworked within the cable trays. Proper care must be taken to ensure that new cables added to the trays are not stressed or intertwined with existing cables. Overhead cables may not cross

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perpendiculars or be suspended in mid-air without supports. No supports may be installed without prior approval from the Owner. All long cable runs must be properly identified at each end and every 100 feet indicating the carried frequency and communication room of origin. All cabling within the building must be cut to proper length.

H. The Contractor shall obtain written permission from the Owner before proceeding with any work which requires cutting into or through any part of the building structures such as, but not limited to, girders, beams, concrete, carpeted or tiled floors, partitions or ceilings. The Contractor shall also consult with the General Contractor before cutting into or through any part of the building structures where fireproofing or moisture proofing could be impaired.

3.2 INSTALLATION

A. System equipment shall not be installed until the environment is free of dust. A dust-free environment shall be considered one in which all construction work has been completed and the air handling system for the area has been operated continuously for at least two weeks with a filter change after one week. During and following installation of the system equipment, relay assemblies and equipment cabinets, the air handling system shall be kept operational continuously and shall be adjusted to maintain a positive pressure relative to building spaces outside the areas of installation. Openings into the installation spaces shall be kept closed, filters shall be changed at frequent intervals, equipment enclosures shall be kept closed, covers shall be installed and any other provisions for keeping the equipment, assemblies, and cabinets clean and free of dust and deliver shall be employed.

B. Verify exact location and sizes of all conduit runs and back boxes prior to rough-in.

C. All switches, connectors, outlets, etc. shall be clearly, logically, and permanently labeled during installation.

D. All items of equipment related to the AV system shall be installed in the designated positions as defined on the drawings.

E. All wiring terminations shall be trimmed to the required length for proper system operation and neatly dressed. No excess wire loops shall remain in the final system unless required for maintenance access. Each system wire and cable shall be clearly marked at each end.

F. All audio and video interconnections shall use the highest quality signal path available.

3.3 WIRING

A. Wiring within equipment enclosures shall be neatly grouped or tied or run in plastic snapcover wireway sections. All connections to panel mounted devices shall employ compression attached full 360° ring type or 'push-on' type terminators securely fastened to the device terminals. Wiring shall run behind the panel in a manner that is not visible from the operator's position. A 3" termination loop shall be formed immediately adjacent to each terminal.

B. Terminal strips shall be fully insulated but allow insertion of test equipment probes. Each terminal segment shall be numbered to correspond with the drawings and conductor identification numbers.

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C. All wire and cable shall extend to each outlet location with complete electrical continuity and without any shorts or grounds. Cables shall run uninterrupted and un-spliced to each remote device.

D. Cables shall be routed so as to maintain a separation of at least 2 feet from all heat sources and from ballasts, transformers, dimmers and all other sources of electromagnetic interference.

E. Care shall be exercised during installation not to damage the cable insulation. Damaged cables shall be removed and replaced.

F. Each cable termination shall be tagged and labeled.

G. Wire color coding for all AV cabling shall be at the option of the Contractor, but each individual conductor shall be the same color throughout its entire length.

H. After testing is complete, audio levels on all systems shall be set to levels satisfactory to the Owner.

3.4 SYSTEM CONFIGURATION

A. Contractor shall provide for configuration of all devices and software into a complete and fully operational AV System.

1. All configuration files shall be provided to the Owner as part of the close-out package

a. Contractor shall maintain ownership of any custom software files.
b. Contractor shall extend to the Owner a perpetual license for use and modification of any custom software files when used with systems provided as part of this scope of work.

B. During the installation phase of the project, the Contractor shall work with the Owner to establish the baseline configuration requirements for the different AV elements.

3.5 CONFIGURATION REQUIREMENTS

A. An IP Addressing Plan shall be coordinated, developed, and finalized with the Owner and submitted for approval prior to implementation.

B. VLAN(s) shall be configured to support the LAN and as identified during Owner network coordination efforts.

C. Configure AV devices for centralized management via an Owner provided workstation connected to the network. Configuration and management software for the various network components shall be installed on the workstation. Training shall include management of the AV devices via the management workstation.

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3.6 TESTING

A. Project Testing: The overall Audio Visual Systems shall not be considered complete until On-Site Testing is completed. The purpose is to test the complete system and demonstrate that all specified features and performance criteria are met. All requirements of the specification shall be tested.

B. Contractor shall follow the Avixa/ANSI 10:2013 *Audiovisual Systems Performance Verification* testing and documentation process and submit a completed testing plan prior to final Owner and Design Professional testing.

1. Design Professional may elect to request retesting of individual rooms following the Avixa/ANSI 10:2013 standard until satisfied that systems are properly installed and configured.

C. For any system or equipment types not covered in the Avixa/ANSI 10:2013 standard, Contractor shall provide the proposed test plan/procedures for each testing phase for review by the Owner or Design Professional. The test plan for each phase of testing shall detail the objectives of all tests. The tests shall clearly demonstrate that the system and its components fully comply with the requirements specified herein. The submission of Test Plans shall adhere to the following:

1. A draft test plan shall be presented to the Owner at least forty-five (45) days prior to the scheduled start of each test.
2. A workshop for reviewing comments shall be conducted with the Owner at least thirty (30) days prior to the scheduled start of each test.
3. A final test plan shall be submitted to the Owner at least fourteen (14) days prior to the scheduled start of each test.
4. Test plans shall contain at a minimum:

a. Functional procedures including use of any test or sample data.
b. Test equipment is to be identified by manufacturer and model.
c. Interconnection of test equipment and steps of operation shall be defined.
d. Expected results required to comply with specifications.
e. Testing matrix referencing Specification requirements with specific test procedures.
f. Record of test results with witness initials or signature and date performed.
g. Pass or fail evaluation with comments.

D. The test procedures shall provide conformity to all Specification requirements. Satisfactory completion of the test procedure is necessary as a condition of system acceptance.

E. All Test plans must be reviewed by the Owner. To successfully complete a test, the test document must be signed and dated by both the Contractor and the Owner.

F. The Owner will review, witness and validate the execution of all formal test procedures prepared by the Contractor and deliverable under the contract to assure the tests cover all requirements and that there is a conformity between the conducted test, the test results and Specification requirements.

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G. Documentation verification both interconnects and operationally, shall be part of the test. Where documentation is not in accordance with the installed system interconnect and operating procedures, the system shall not be considered accepted until the system and documentation correlate.

H. The Contractor shall provide the Owner or Owner representative the opportunity to participate in any or all of tests.

I. Test Reports: The Contractor shall prepare, for each test, a test report document that shall certify successful completion of that test. Submit to the Owner's representative for review and acceptance within seven (7) days following each test. The test report shall contain, at a minimum:

1. System power measurement results and settings
2. Commentary on test results
3. A listing and discussion of all discrepancies between expected and actual results and of all failures encountered during the test and their resolution.
4. Complete copy of test procedures and test data sheets with annotations showing dates, times, initials, and any other annotations entered during execution of the test.
5. Signatures of persons who performed and witnessed the test
6. Test Resolution: Any discrepancies or problems discovered during these tests shall be corrected by the Contractor at no cost to the Owner. The problems identified shall be corrected and the percentage of the entire system re-tested determined by the Owner before any subsequent testing is performed.

3.7 CLEANING

A. Remove all unnecessary tools and equipment, unused materials, packing materials, and debris from each area where work has been completed unless designated for storage.

3.8 TRAINING

A. The Contractor shall provide the Owner specified trainees with detailed as-built information. The training shall provide trainees with a working knowledge of the system design and layout, ability to configure and monitor the system, and troubleshooting methods and techniques. In addition, the training shall cover testing, maintenance, and repair procedures for all equipment and applications, which are provided under this Specification.

B. Course materials shall be delivered to the Owner. Final delivery of the course materials shall include a master hard copy of all materials and an electronic copy in a format reviewed in advance by the Owner. The Contractor shall supply a video recording of each training course.

C. All training shall be completed a minimum of two weeks prior to the system becoming operational and utilized by the Owner. Training schedule subject to the Owner's review.

3.9 ACCEPTANCE

A. Acceptance will be withheld until the following have been completed successfully:

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1. Acceptance of all submittals
2. Delivery of final documentation
3. Successful testing
4. Completion of training
5. Demonstrate system to designated Owner personnel as required by applicable sections of these specifications. Use submitted operation and maintenance manual as reference during demonstration and training. Demonstrate as-built records are in format required and can lead troubleshooting technicians to port level of detail in field.

END OF SECTION 27 41 00

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SECTION 27 52 23

NURSE CALL/CODE BLUE SYSTEMS

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

B. Related Sections:

1. Division 07 – Through-penetration Firestop Systems
2. Division 26 – Common Work Results for Electrical
3. Division 26 – Low Voltage Electrical Power Conductors and Cables
4. Division 26 – Grounding and Bonding for Electrical Systems
5. Division 26 – Hangers and Supports for Electrical Systems
6. Division 26 – Raceways and Boxes for Electrical Systems
7. Division 26 – Identification for Electrical Systems
8. Division 27 – General Requirements for Telecommunications
9. Division 27 – Common Work Elements for Communications Systems
10. Division 27 – Network Communications Systems
11. Division 27 – Two-Way Communications System
12. Division 27 – Audiovisual Systems
13. Division 27 – Nurse Call/Code Blue
14. Division 28 – Common Work Elements for Electronic Safety and Security
15. Division 28 – Physical Electronic Safety and Security
16. Division 28 – Video Surveillance System

C. Section includes visual/tone nurse-call system.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Equipment cabinets.
2. Cabling diagrams.
3. Station installation details.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

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1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Compatibility: System shall be capable of integration with any brand of phone system (wired or wireless), staff locating system, CCTV, and fire-alarm system.

C. Electrical Components, Devices, and Accessories: Listed and labeled according to UL 1069 as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for 2 years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within 2 years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

C. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 NURSE-CALL SYSTEM GENERAL REQUIREMENTS

A. Manufacturer: Rauland-Borg Responder 5000.
1. Accepted Alternate: Jeron 790 Systems.

B. Station Zones: Able to program 256 station zones for each master station in the network with a minimum of 8 priority levels and addressable visual and audible annunciation of audible devices such as smoke detectors and door contacts.

C. System shall provide integrated and centralized "Code Blue" and "Staff Emergency" calls.

D. Expansion Capability: Equipment ratings, housing volume, spare keys, switches, relays, annunciator modules, terminals, and cable conductor quantities adequate to increase the number of stations in the future by 25 percent above those indicated without adding internal or external components or main trunk cable conductors.

E. Resistance to Electrostatic Discharge: System, components, and cabling, and the selection, arrangement, and connection of materials and circuits, shall be protected against damage or diminished performance when subjected to electrostatic discharges of up to 25,000 V in an environment with a relative humidity of 20 percent or less.

F. Equipment: Microprocessor, electronic, modular.

G. Master Nurse-Call Station: Programmed via a PC.

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H. Wall-Mounted Component Connection Method: Components connect to system wiring in back boxes with factory-wired plug connectors.

I. Telephone Interface: Permit use of wired and wireless telephones to execute nurse-call master station functions.

J. Third-Party Pager Interface: Programmable to send tone, numeric, and alphanumeric message to pocket pagers or personal digital assistants and to use industry standard-protocol, RS-485 interface.

2.2 VISUAL/TONE NURSE-CALL SYSTEM

A. Operational Requirements:

1. Patient Station Call: Lights a steady call-placed lamp on the station, steady lamps in the zone light and corridor dome light associated with the patient's room, and steady lamps at the central annunciator and other system display devices and displays message on master and staff/duty stations. At the same time, it sounds a programmed tone at intervals, at the respective annunciator and master and staff/duty stations. Legends at the central annunciator and master station identify the calling station.
2. Pull-Cord-Call Station Call: Flashes a call-placed lamp on the station and distinctive-color lamps in the zone light and corridor dome light and at the central annunciator and staff/duty stations. At the same time, it sounds a programmed tone at intervals, at the central annunciator and master and staff/duty stations. A legend at the master station identifies the calling station, priority as programmed, and bed identification.
3. Emergency-Call Station Call: Produces the same responses as pull-cord-call station calls except rapidly flashing red emergency digital display and tone repetition rates are more frequent, tone frequency is higher, and lamps in the zone light and corridor dome light are a different color. Indicator lamps may be turned off and the system reset only at the calling station. Displays message on pocket pagers, sounds programmed tone on phones, and displays message on display equipped phones.
4. System Reset: Operating reset button at the originating station cancels signals associated with the call. Illuminates a green digital display on the patient station and log presence on the master station.
5. Cord-Set Removal: Initiates a patient station call when the cord set is removed from the jack in the patient station faceplate. Displays location and "cord removed" message on master station, pocket pagers, and display equipped phones. Inserting a cord-set plug or a dummy plug into the jack and operating the station reset button resets the call.
6. Patient Control Unit: Controls entertainment volume and channel selection. Nurse button on the unit initiates a patient station call. Integral speaker reproduces entertainment sound.
7. Emergency Bath Station Call: Illuminates the digital display on the emergency bath station; rapidly flashes white dome lamp; displays location, priority, and bath on master station; and sounds programmed tone on master station display equipped phones and pocket pagers.
8. Staff/Duty Station Operation: Operation shall be identified to patient station except the message staff shall display on all devices when the staff call button is activated.
9. Privacy Key Activation: When privacy key is activated on patient station, the system shall disconnect the patient station microphone and slowly flash yellow privacy digital display on the patient station. Displays "privacy" on master station when selecting this room/bed.

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B. Central Annunciator:

1. Lamp type.
2. Lamp Legends: Machine lettered and legible from a distance of at least 48 inches when a call is present. Legend shall identify initiating station and priority of call.
3. Power-on Indicator: Digital, or push-to-test switch.
4. Audible Signal: Electronic tone.

C. Central Equipment Cabinet:

1. Lockable metal.
2. Houses power supplies, controls, terminal strips, and other components.
3. Power-on indicator lamp.

D. Single-Patient Station: Call-placed lamp, reset push button, and polarized receptacle matching cord-set plug; mounted in a single faceplate.

E. Staff/Duty Stations: A minimum of two call lamps, one for routine calls and one for emergency calls; and an audible tone signal device.

2.3 SYSTEM COMPONENTS

A. Emergency-Call Station: Locking-type push button, labeled "Push to Call Help"; reset trigger to release push button and cancel call; and call-placed lamp, mounted in a single faceplate.

B. Emergency-Bath Station:

1. Consists of a sliding, chemical-resistant, ABS red fascia marked with the word "URGENT" in bold letters.
2. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
3. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
4. Water resistant and able to withstand routine cleaning and chemical disinfectants.
5. Uses magnetic reed switch technology for reliability and corrosion resistance.
6. Mounts on a single-gang electrical box wire to the respective patient station or input controller.

C. Staff, Emergency Station:

1. Consists of a sliding, chemical-resistant, ABS red fascia marked with the word "EMERGENCY" in bold letters.
2. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
3. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
4. Mounts on a single-gang electrical box wire to the input controller.

D. Pull-Cord-Call Station:

1. Pull-Down Switch: Lever-locking type, labeled "Pull Down to Call Help."

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2. Reset trigger.
3. Call-placed lamp.
4. Water-resistant construction.

E. Patient Control Unit:

1. Equipped with plug and 96-inch long white cord.
2. Ethylene oxide, sterilizable.

F. Pillow Speakers:

1. Eight-conductor, DIN, flexible PVC jacketed cable.
2. Contain nurse-call button, volume control, speaker, and channel control in molded flame-retardant ABS housing.
3. Cord: 96 inches long with sheet clip.

G. Call-Button Plug:

1. Designed to plug into patient station cord-set receptacle.
2. Button switches call circuit.
3. Two plugs for every 10 patient beds.

H. Dummy Plugs:

1. Designed to plug into patient station cord-set receptacle when call-button plug or patient cord set is not used.
2. Three plugs for every 10 patient beds.

I. Indicator Lamps: Digital type with rated life of 20 years unless otherwise indicated.

J. Station Faceplates:

1. Stainless steel, a minimum of 0.0375 inch thick.
2. Finish: Brushed.
3. Machine-engraved labeling identifies indicator lamps and controls.

K. Corridor Dome Lights and Zone Lights:

1. Three-lamp signal lights.
2. Lamps: Front replaceable without tools, low voltage with rated life of 7500 hours. Barriers are such that only one color is displayed at a time.
3. Lenses: Heat-resistant, shatterproof, translucent polymer that will not deform, discolor, or craze when exposed to hospital cleaning agents.

L. Cable:

1. Conductors: Jacketed single and multiple, twisted-pair copper cables.
2. Sizes and Types: As recommended by equipment manufacturer.
3. Cable UL-Listed and labeled for plenum installation.

M. Grounding Components: Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."

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2.4 SOFTWARE REQUIREMENTS

A. Telephone System Interface:

1. Permits use of wired and/or wireless telephones to execute nurse-call master station.
2. Two-way communication with patient and staff stations.
3. Two-way communication with the master nurse station.
4. "All Call," group call, and staff call paging.
5. Capable of being programmed to forward calls destined for a master nurse station to any connected telephone.
6. Telephones connected to the telephone interface shall have the same call tone ring patterns as those generated at the master nurse station.
7. Telephones having a display shall indicate the call type, priority code, and the calling station number of incoming calls.
8. Telephones shall be capable of initiating a service request for a particular patient station, logging calls on the master station's reminder list, and activating door lock mechanisms associated with a call station.
9. Capable of routine setup and configuration changes using the keypads on display telephone and/or the master station.

B. Display Telephones:

1. Digital telephones for use as mini-master nurse-call stations.
2. Digital display shall indicate the call type, priority code, and calling station number of incoming calls.
3. Ring patterns shall be identical to those generated at the master station.
4. Capable of two-way communication with patient and staff stations and the master station, and other telephones interfaced with the system.
5. Capable of placing or answering outside calls when interfaced with the facility telephone system.
6. Capable of "All Call," group call, and staff call paging and of initiating service requests, logging calls to the reminder list, and activating optional door controls.

C. Third-Party Pocket Pager Interface:

1. Equipped with a standalone pocket pager interface.
2. Connects with the facility paging system and transmit alphanumeric messages to the pocket pagers as preprogrammed in the system.

D. Statistical Software:

1. Includes a data statistical software package that stores, sorts, and analyzes activities occurring on the nurse-call system network.
2. Windows based and operated on a PC that is connected to the nurse-call system network.
3. Stores events on the PC's hard disk. Accumulation of these stored events shall make up the database that is used to generate reports and statistics.
4. Events stored by the software shall include date, day of week, time, ward, priority, and room number.
5. Capable of assigning a patient name to bed number.
6. Stored events shall include, but not be limited to, calls placed, call priority, calls cancelled at the nurse station, calls cancelled at the point of origin, regenerated calls, calls

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answered, calls sent to pager interface, staff presence registration, staff presence cancellation, service request, service cancellation, and system and network error messages.

E. Data Analysis Software:

1. Capable of analyzing the stored information and generating computed analysis.
2. Analysis of the database can be conducted by specifying one, many, or all of the following parameters of the database: date, day of week, time, wards, priority, and room number.
3. Analysis shall include, but not be limited to, total number of calls placed, average call response time (from call placed to call cancellation), total number of presence registrations, average presence time in a room, total number of service requests, average response time (from audio answer to call cancellation), and average ring time (from call placed to audio answer).

F. Statistical Software Package:

1. Capable of displaying multiple calls/events on a PC monitor or on a RS-485 data-bus-driven digital display panel.
2. Calls from patient or staff stations and associated devices shall be displayed by priority. Display shall be customizable as follows:

a. Choice of color by type of call.
b. Choice of display size (character size).
c. Choice of priority levels, type of events, points of origin.
d. Identification of facility.
e. Identification of ward.
f. Identification of patient with specific patient information.

2.5 CONDUCTORS AND CABLES

A. Audio Cables:

1. Conductors: Jacketed, twisted-pair and twisted-multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.
2. Insulation: Thermoplastic, not less than 1/32 inch thick.
3. Minimum Shielding Coverage on Conductors: 60 percent.
4. Plenum Cable: Listed and labeled for plenum installation.

B. Data Cable and Hardware: Category 6 balanced twisted-pair cabling and hardware. Comply with requirements in Section 271500.

C. Power Conductors and Cables: Copper, solid, No. 20 AWG. Comply with requirements in Section 26519 "Low-Voltage Electrical Power Conductors and Cables."

D. Grounding Conductors and Cables: Copper, stranded, No. 16 AWG. Comply with requirements in Section 260516 "Low-Voltage Electrical Power Conductors and Cables."

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PART 3 - EXECUTION

3.1 INSTALLATION

A. Wiring Method:

1. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used.

   a. Install plenum cable in environmental air spaces, including plenum ceilings.
   b. Conceal raceway and cables except in unfinished spaces.

2. Conduit and Boxes: Comply with requirements in Section 270528 "Pathways for Communications Systems.

B. Install cables without damaging conductors, shield, or jacket.

C. Do not bend cables, while handling or installing, to radii smaller than as recommended by manufacturer.

D. Pull cables without exceeding cable manufacturer's recommended pulling tensions.

1. Pull cables simultaneously if more than one is being installed in same raceway.
2. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
3. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, that will not damage media or raceway.

E. Install exposed raceways and cables parallel and perpendicular to surfaces or exposed structural members and follow surface contours. Secure and support cables by straps, staples, or similar fittings designed and installed so as not to damage cables. Secure cable at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, or fittings.

F. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

G. Separation of Wires: Separate speaker/microphone, line-level, speaker-level, and power-wiring runs. Run in separate raceways or, if exposed or in same enclosure, provide 12-inch minimum separation between conductors to speaker/microphones and adjacent parallel power and telephone wiring. Provide separation as recommended by equipment manufacturer for other conductors.

H. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Install terminal cabinets where there are splices, taps, or terminations for eight or more conductors.

I. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks if required.

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J. Identification of Conductors and Cables: Comply with requirements in Section 270553 "Identification for Communications Systems" for cable administration, cable schedule, and cable and wire identification.

K. Equipment Identification:

1. Comply with requirements in Section 270553 "Identification for Communications Systems" for equipment labels and signs and labeling installation requirements.
2. Label stations, controls, and indications using approved consistent nomenclature.

3.2 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other signal impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding except at connection to main building ground bus.

C. Grounding Provisions: Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Schedule tests a minimum of seven days in advance.
2. Report: Submit a written record of test results.
3. Operational Test: Perform an operational system test and demonstrate proper operations, adjustment, and sensitivity of each station. Perform tests that include originating station-to-station and "All Call" messages and pages at each nurse-call station. Verify proper routing, volume levels, and freedom from noise and distortion. Test each available message path from each station on the system. Meet the following criteria:

a. Speaker Output: 90 dB plus or minus 3 dB, 300 to 3000 Hz, reference level threshold of audibility 0 dB at 0.02 mPa of sound pressure.
b. Gain from patient's bedside station to nurse station, with distortion less than 65 dB (plus or minus 3 dB, 300 to 3000 Hz).
c. Signal-to-Noise Ratio: Hum and noise level at least 45 dB below full output.

4. Test Procedure:

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a. Frequency Response: Determine frequency response of two transmission paths by transmitting and recording audio tones.
b. Signal-to-Noise Ratio: Measure the ratio of signal to noise of the complete system at normal gain settings using the following procedure: Disconnect a speaker/microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure the ratio of signal to noise and repeat the test for four speaker microphones.
c. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 300, 400, 1000, and 3000 Hz into each nurse-call equipment amplifier and measure the distortion in the amplifier output.

D. Retesting: Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify, by the system test, that the total system meets these Specifications and complies with applicable standards. Report results in writing.

E. Inspection: Verify that units and controls are properly labeled, and interconnecting wires and terminals are identified.

F. Prepare test and inspection reports.

3.4 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sound levels and controls to suit actual occupied conditions. Provide up to 3 visits to Project during other-than-normal operating hours for this purpose.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel and caregiver staff to adjust, operate, and maintain nurse-call equipment.

END OF SECTION 27 52 23

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SECTION 28 05 00

COMMON WORK ELEMENTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

B. Related Specification Sections:

1. Division 07 – Through-penetration Firestop Systems
2. Division 26 – Common Work Results for Electrical
3. Division 26 – Low Voltage Electrical Power Conductors and Cables
4. Division 26 – Grounding and Bonding for Electrical Systems
5. Division 26 – Hangers and Supports for Electrical Systems
6. Division 26 – Raceways and Boxes for Electrical Systems
7. Division 26 – Identification for Electrical Systems
8. Division 27 – General Requirements for Telecommunications
9. Division 27 – Common Work Elements for Communications Systems
10. Division 27 – Network Communications Systems
11. Division 27 – Two-Way Communications System
12. Division 27 – Audiovisual Systems
13. Division 27 – Nurse Call/Code Blue
14. Division 28 – Common Work Elements for Electronic Safety and Security
15. Division 28 – Physical Electronic Safety and Security
16. Division 28 – Video Surveillance System

C. Reference Symbols:

1. All device symbols are defined by the appropriate symbol schedule on the symbols and abbreviations sheet in the communications system drawing package. Not all device symbols as indicated may be required for the project.

   a. Because of the scale of the drawings, symbols are shown on the drawings as close as possible to the mounting location. Contractor shall coordinate exact locations with architectural drawings and all affected trades prior to submittal of shop drawings.

D. Abbreviations:

1. ASIS: American Society Industrial Security (International)
2. AP: Wireless Access Point
3. A/V: Audio Visual Systems – For purposes of this specification section A/V systems shall include all Media Management, Video Broadcasting, Intercommunications (Paging/Public Address, Clock, Auxiliary Sound), Video Intercom, Emergency Communications, Mass Notification, Master Antenna (MATV) and Distance Learning Systems.
4. AVI Audio Visual Systems Integrator: Shall be a qualified contractor

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experienced in the installation and certification of A/V systems. The AVI contractor shall be responsible for the design, testing and certification of all audio/visual systems including but not limited to Intercommunications, TV Distribution, Audio/Visual, Master Antenna and Bi-Directional Antenna systems as well as all structured cabling systems supporting these technologies. The AVI shall be RCDD registered certified for the installation and commissioning of all structured cabling networks and communications systems.

5. BACnet: A communications protocol for building automation and control networks as outlined in ISO 16484-5 and ASHRAE/ANSI Standard 135.
6. BAS: Building Automation System
7. BICSI: Building Industry Consultant Services International- International organization whose primary objective is to enhance the reputation and skills of companies and individuals employed in the telecommunications and security industries by ensuring that current and developing standards are maintained.
8. CATV**:** Community Antenna Television System – Cable TV Network
9. CCD: Charge-coupled device.
10. CCTV: Closed Circuit Television Surveillance System.
11. CMOS: Complementarymetal–oxide–semiconductor
12. CP: Consolidation Point - Local Interconnection Point between horizontal cables from the building IDF/MDF rooms and horizontal cables for the furniture drops.
13. CPU: Central Processing Unit
14. DP: Demarcation Point - The point of interface between the Communications Networks, MATV, any Auxiliary Systems, and the associated Service Providers or Public Utilities. Also known as Entrance Facility. Shall also serve as the primary termination point for all incoming OSP cabling as well as the primary main grounding bus-bar for all communications systems. Refer to project documents for exact location and termination requirements.
15. DVR Digital Video Recorder.
16 DTS: Digital Termination Service: A microwave-based, line-of-sight communications provided directly to the end user.
17. DVT Remote digital viewing terminal which shall serve as the video surveillance systems' operator HMI terminal remote from the primary rack mounted HMI.
18. EMI: Electromagnetic interference.
19. EMT: Electric Metallic Tubing.
20. ESS Electronic Security Systems – Including but not limited to; intrusion detection, physical access control, CCTV video surveillance, electronic perimeter detection, duress alarm, programmable logic controllers (PLC), supervisory control and data acquisition (SCADA), integrated security management platforms and electronic screening systems.
21. ESSI: Electronic Security Systems Integrator– Shall be a qualified contractor experienced in the design, programming, installation, testing and certification of all Intrusion Alarm, Access Control, CCTV Surveillance and Security Management Systems. The ESSI shall have a registered RCDD professional review and seal the designs, installations and certifications of all structured cabling networks related to the installation of any IP based electronic security system.
22. EVAC: UL Listed Emergency Voice Evacuation System. Not to be confused with the building; Public Address/Intercom, Intercommunications and/or Mass Notification systems.
23. FAS: Fire Alarm System

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24. FASI: Fire Alarm System Integrator – Shall be a NICET Level III certified contractor experienced in the installation, programming, testing and certification of Rescue Assistance, Protected Premises and Central Station Signaling Fire Alarm Systems as defined by NFPA 72.
25. GAP Graphic Annunciator Panel – A custom fabricated fixed display panel providing operational control and visual display of all alarm and system functions related to the operation of the FAS and/or ESSM as described in related specification sections.
26. GFI: Ground fault interrupter.
27. GUI: Graphic User Interface – A specialized program employing graphical display maps of a facility and/or site which, also provides a manual user interface for all system functions and operations by utilizing control and annunciation ICON's from dedicated human machine interface terminals.
28. HMI: Human Machine Interface – A Computer-operated, video control terminal complying with FCC Part 15 CFR Title 47, Subparts A and B, and shall utilize multiple dynamic GUI based displays for annunciation and control LCD flat panel computer monitor or display screen as defined by related specification sections.
29. ICS: Intercommunications system – Shall include but not limited to all intercoms, public address, clock, program, and auxiliary sound or emergency communications systems as defined by related specification sections.
30. IDF: Intermediate Distribution Frame – The room/space that shall serve as the local termination point for all horizontal and backbone cabling. Also shall be known as Equipment Room (ER), Horizontal Cross-Connect (HC) or Floor Distribution (FD).
31. IDS: Intrusion Detection System.
32. I/O: Input/Out – Commonly associated with dry/contact relay based digital integration.
33. ITS: Information Transport Systems – For purposes of this specification section ITS shall include all data and telecommunications communications systems including but not limited to all Data, Telephone, Intercommunications (Paging/Public Address), TV Distribution Systems (MATV) and Audio Visual Systems (A/V) and IP based CCTV Surveillance Systems.
34. ITSI: Information Technology System Integrator – Shall be a qualified contractor experienced in the installation and certification of all data, telecommunications and A/V systems. The ITSI shall be responsible for the design, testing and certification of Data, Telephone communications systems and all structured cabling systems supporting these technologies.
35. LAN: Local Area Network
36. LCD: Liquid-crystal display.
37. LED: Light Emitting Diode.
38. LV: Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
39. MATV: Master Antenna System – Shall include all TV and media management distribution cabling, termination jacks, head-end components, control, equipment racks, amplifiers, projection equipment and video monitoring devices as defined by the project drawings and related specification sections.
40. MDF: The Main Distribution Frame – The room/space that shall serve as the primary termination point for all backbone cabling to each IDF locations and horizontal connection point for local communication drops. May also serve as a local IDF location as well as the cross-connection and interconnection of all entrance cables from the DP for all PSTN and WAN connections. Also shall be known as Main Cross Connect

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(MC), Telecommunications Room (TR) and/or Campus Distributor (CD)

41. M-JPEG: Motion – Joint Photographic Experts Group.
42. MPEG: Moving picture experts group.
43. NEC: National Electric Code
44. NEMA: National Electrical Manufacturers Association
45. NFPA: National Fire Protection Association
46. NTSC: National Television System Committee.
47. NRTL: Nationally Recognized Testing Laboratory.
48. NVR: Network Video Recorder
49. NVS: Network Video Server
50. OTDR: Optical Time Domain Reflectometer
51. OSP: Outside Plant – All cabling associated with building services supporting the incoming service connections to Service Providers, Public Utilities and Wide Area Networks.
52. PA: Public Address or Building Intercommunications System.
53. PACS: Physical Access Control System.
54. PIDS Perimeter Intrusion Detection System
55. PIR Passive Infrared
56. POTS: Plain Old Telephone Service – Analog Telephone Circuit used for the connection of FAX machines, BAS and FAS communications devices and shall be wired upstream of the facility's telephone switch.
57. PSP: Physical Security Professional as registered by the American Society of Industrial Security-International (ASIS)
58. PSTN: Public Switched Telephone Network – Connection to local telephone utility providing local telephony communications service.
59. RCDD BICSI accredited Registered Communications Distribution Designer
60. RFI: Radio-frequency interference.
61. RIGID: Rigid conduit is galvanized steel tubing, with a tubing wall that is thick enough to allow it to be threaded.
62. RS-232: A TIA/EIA standard for asynchronous serial data communications protocol between terminal devices. This standard defines a 25-pin connector and certain signal characteristics for interfacing computer equipment.
63. RS-485: A TIA/EIA standard for multipoint communications protocol.
64. SCADA: Supervisory Control and Data Acquisition – A system used in to monitor and control plant status of facilities scattered over wide geographic areas.
65. SMS: Security Management System – A system incorporating security alarms, door controls, emergency intercoms/paging, duress alarms and surveillance systems all integrated through a single operating platform, providing centralized command and control capability for the various systems via dedicated human machine interface terminals.
66. TCP/IP: The standard communications protocol that implement protocol stack on which the Internet and data communications networks operate
67. TGB: Telecommunications Grounding Busbar – Located in each IDF
68. TMGB Main Grounding Busbar – Located at the building DP/MDF
69. TP: Transition Point – A location in the horizontal cabling where flat under-carpet cable transitions to a horizontal cabling consolidation point (CP).
70. TVSS: Transient voltage surge suppressor
71. VLAN: Virtual LAN – A technique made possible by switching technologies that permits the logical grouping of any number of network devices into one or more sub- networks.
72. UPS: Uninterruptible Power Supply
73. UTP: Unshielded Twisted Pair

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74. VMS: Video Management Software which shall software that incorporates multiple security subsystems (e.g., physical access control, intrusion detection, closed circuit television, intercom) into a single platform and graphical user interface.
75. VoIP: Voice Over IP telephone Network
76. WAN: Wide Area Network
77. WLAN: Wireless Local Area Network

E. Definitions:

1. Contract Documents: The documents consisting of the Form of Agreement between Owner and Contractor, Conditions of the Contract, (General, Supplementary, and other Conditions), Drawings, Specifications and all Addenda issued prior to the execution of the Contract.
2. Contract Drawings: The drawings that form a part of the Contract Documents that provides the graphical representation of the project requirements intended design and/or performance criteria to be delivered by the Contractor.
3. Reference Drawings: A drawing and/or set of drawings produced by a proprietary supplier, manufacturer, subcontractor, or fabricator included in the Contract Documents for informational purposes, providing specific information related to the installation of related appurtenances, components, devices, hardware, products and/or systems. Reference Drawings shall also include any Contract Drawings from prior bid packages that may have pertinent information or require coordination of trades related to this contract.
4. Shop Drawings: A drawing and/or set of drawings produced by the contractor, supplier, manufacturer, subcontractor, or fabricator as a detailed representation of the proper installation of the related, appurtenance, component, device, hardware, product and/or system to be delivered in conformance to the requirements of the Contract Documents.

1.2 SUMMARY

A. This Section contains the overall requirements associated with all Division 28 Specification Sections and includes the project design intent for all electronic security systems (ESS) as well as requirements for submittals, quality assurance, product handling, record documents, project conditions, installation, system performance, demonstrations, testing, training and certifications for all scopes of work related to these systems. Refer to related specification sections and contract drawings for additional information.

1. The Division 26 contractor shall act as the prime contractor for the project and who herein shall be known as the “Contractor”.

B. The ESSI shall be a sub-contractor to the Division 26 contractor and shall have overall responsibility for all designs, equipment and all technical support related to all Division 28 scopes of work and shall ensure full coordination of all work with relationship to the Division 26 contractor as required to provide fully operational security systems as herein specified and in accordance with all requirements of the related specification sections and contract drawings.

C. It shall be the responsibility of the Contractor to furnish and install all necessary cabling, conduits/raceways, cable terminations, controls, systems, equipment, materials, devices, components, electrical power, equipment racks/cabinets and software as well as all

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appurtenances, programming, commissioning and testing necessary to deliver complete and fully operational systems as indicated by all division 28 specification sections and related contract drawings.

1. The installation, performance, features, functions, software and programming criteria as specified herein as well as all related Division 28 specification sections have been designed to offer the maximum system efficiency, ease of operation, occupant safety and the protection of equipment as recommended by the Veterans Administration (VA)and Design Professional.
2. Any deviations from the specified criteria shall be documented, reviewed and agreed to in writing by Owner and Design Professional prior to submission of bids. Refer to Division 1, and all related Division 28 specification sections for any substitutions and/or project deviation requests.

    1) The required information shall include but not limited to: reason for deviation, all differences in performance, operation and function from the herein specified requirements, all benefits and added features to the Owner as a result of the deviations and any additional incurred costs to the Owner for maintenance and long term ownership.
    2) Failure to provide the Owner and Design Professional with the required information shall result in any shop drawing submissions being returned for non-conformance with the contract requirements.

3. The contractor and all sub-contractors for this work shall have read all of the General Conditions, Special Requirements, General Requirements, Division 1 and all related specification sections and in the execution of all work shall be bound by all of the conditions and requirements therein.
4. Prior to the submission of the Bid any discrepancies or inconsistencies noted within these specifications and/or the project drawings shall be brought to the immediate attention of the Owner and Design Professional.
5. All device symbols are defined by the appropriate symbol schedules as indicated by the symbol and abbreviation drawing sheets for each discipline. The Contractor shall coordinate exact locations with all architectural, mechanical, electrical, reflected ceiling, furniture drawings and door hardware specifications as well as all affected trades prior to submittal of bids.
6. All symbols are shown on the contract drawings as close as possible to their intended location. Contractor shall coordinate the installation of all equipment, devices, controls, components, cabling conduits/raceways and integration of other systems with all affected trades and specified system integrators. The contractor shall document all coordination requirements at the time of shop drawing submission.

D. Drawings for this work are diagrammatic and intended to convey the extent, general arrangement and locations of the work. Because of the scale of the drawings, certain basic items such as access panels, conduits, cabinet sizes, penetration sleeves, pull boxes, back-boxes and junction boxes may or may not be shown on the contract drawings. Include all items where required by code and related specification sections for proper installation of all work.

E. Where ambiguity exists between the project specifications and the contract drawings, the superior in system performance regardless of cost shall prevail and shall be delivered by the Contractor at no additional expense to the project.

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1. Project specifications and drawings may not deal individually with every part, control, device, component, or appurtenance which may be required to produce the equipment performance for the specified system and/or as required for compliance with all specified systems integration.

    1) Include such items and components, as required, for complete operational systems as defined by the project documents, whether or not specifically indicated. The contractor shall be responsible for providing conduits/raceways, cable terminations, controls, systems, equipment, materials, devices, components, electrical power, equipment racks/cabinets, software, programming, commissioning, testing and all appurtenances as well as the integration of any ancillary systems or Owner provided equipment/components/systems.
    2) Coordinate with other applicable trades in submittal of shop drawings and the installation of all systems. All shop drawings shall detail space conditions in order to accommodate other concerned trades, all equipment locations are subject to final review by the Owner and Design Professional.

1.3 REFERENCES

A. References to industry and trade association standards as well as all building codes are minimum installation requirements. The codes, standards and agencies listed below shall form a part of this specification section and all work shall comply with the latest adopted standards.

B. The publications listed below (including amendments, addenda, revisions, supplement, and errata) form a part of this and all related division 28 specification sections to the extent referenced. The publications are referenced in the text by the basic designation only.

C. Where the contract drawings and specifications mandate a greater requirement or performance than those specified by any of the below referenced codes and standards, the Contract Documents shall then be the governing requirements for this project. The minimum codes and standards to be applied for this project shall be the following:

1. American National Standards Institute (ANSI)/ International Code Council (ICC):

    a. A117.1 - Standard on Accessible and Usable Buildings and Facilities

2. American National Standards Institute (ANSI)/ Security Industry Association (SIA):

    a. AC-03 - Access Control: Access Control Guideline Dye Sublimation Printing Practices for PVC Access Control Cards
    b. CP-01-00 - Control Panel Standard-Features for False Alarm Reduction
    c. PIR-01-00 - Passive Infrared Motion Detector Standard - Features for Enhancing False Alarm Immunity
    d. TVAC-01 - CCTV to Access Control Standard - Message Set for System Integration

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3. American National Standards Institute (ANSI):

   a. 330-09 - Electrical Performance Standards for CCTV Cameras
   b. 375A-76 - Electrical Performance Standards for CCTV Monitors

4. American National Standards Institute (ANSI):

   a. ANSI S3.2-99 - Method for measuring the Intelligibility of Speech over Communications Systems

5. American Society for Testing and Materials (ASTM)

   a. B1-07 - Standard Specification for Hard-Drawn Copper Wire
   b. B3-07 - Standard Specification for Soft or Annealed Copper Wire
   c. B8-04 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
   d. C1238-97 (R03) - Standard Guide for Installation of Walk-Through Metal Detectors
   e. D2301-04 - Standard Specification for Vinyl Chloride Plastic Pressure Sensitive Electrical Insulating Tape

6. Department of Justice: American Disability Act (ADA)

   a. 28 CFR Part 36-2010 - ADA Standards for Accessible Design

7. Federal Communications Commission (FCC):

   a. (47 CFR 15) Part 15 - Limitations on the Use of Wireless Equipment/Systems

8. Federal Information Processing Standards (FIPS):

   a. FIPS-201-1 - Personal Identity Verification (PIV) of Federal Employees and Contractors

9. Federal Specifications (Fed. Spec.):

   a. A-A-59544-08 - Cable and Wire, Electrical (Power, Fixed Installation)

10. Owner Accountability Office (GAO):

    a. GAO-03-8-02 - Security Responsibilities for Federally Owned and Leased Facilities

11. Homeland Security Presidential Directive (HSPD):

    a. HSPD-12 - Policy for a Common Identification Standard for Federal Employees and Contractors

12. Institute of Electrical and Electronics Engineers (IEEE):

    a. 81-1983 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
    b. 802.3af-08 - Power over Ethernet Standard
    c. 802.3at-09 - Power over Ethernet (PoE) Plus Standard

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d. C2-07 - National Electrical Safety Code
e. C62.41-02 - IEEE Recommended Practice on Surge Voltages in Low-
f. Voltage AC Power Circuits
g. C95.1-05 - Standards for Safety Levels with Respect to Human Exposure in Radio Frequency Electromagnetic Fields

13. International Building Code (IBC)
14. International Organization for Standardization (ISO):

a. 7810 – Identification cards – Physical characteristics
b. 7811 – Physical Characteristics for Magnetic Stripe Cards
c. 7816-1 – Identification cards - Integrated circuit(s) cards with contacts - Part 1: Physical characteristics
d. 7816-2 – Identification cards - Integrated circuit cards - Part 2: Cards with contacts - Dimensions and location of the contacts
e. 7816-3 – Identification cards - Integrated circuit cards - Part 3: Cards with contacts - Electrical interface and transmission protocols
f. 7816-4 – Identification cards - Integrated circuit cards - Part 11: Personal verification through biometric methods
g. 7816-10 – Identification cards - Integrated circuit cards - Part 4: Organization, security and commands for interchange
h. 14443– Identification cards - Contactless integrated circuit cards; Contactless Proximity Cards Operating at 13.56 MHz in up to 5 inches distance
i. 15693 – Identification cards -- Contactless integrated circuit cards - Vicinity cards; Contactless Vicinity Cards Operating at 13.56 MHz in up to 50 inches distance
j. 19794 – Information technology - Biometric data interchange formats

15. The Joint Commission (TJC) formally - Joint Commission on Accreditation of Healthcare Organizations (JCAHO)

16. National Electrical Contractors Association

a. 303-2005 – Installing Closed Circuit Television (CCTV) Systems

17. National Electrical Manufactures Association (NEMA):

a. 250-08 – Enclosures for Electrical Equipment (1000 Volts Maximum)
b. TC-3-04 – PVC Fittings for Use with Rigid PVC Conduit and Tubing
c. FB1-07 – Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable

18. National Fire Protection Association (NFPA):

a. 70-2011 – National Electrical Code (NEC)
b. 72-2010 – National Fire Alarm and Signaling Code
c. 90A 2009 – Installation of Air Conditioning and Ventilating Systems
d. 101-2009 – Life Safety Code
e. 731-2008 – Standards for the Installation of Electric Premises Security Systems
f. 99-2005 – Health Care Facilities

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1.4 SUBMITTALS

A. In addition, to all submittal requirements as stipulated by Division 01 specifications sections, the Contractor shall provide all shop drawing submittals in accordance with the following:

1. The Owner and Design Professional approval shall be obtained for all equipment and material before delivery to the job site. Delivery, storage, or installation of equipment or material which has not had prior approval will not be permitted at the job site.
2. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings, and other data necessary for the Owner to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify equipment being submitted.
3. Submittals shall be provided as a complete submission, no partial submissions will be accepted. Failure to provide a complete submission shall result in all submittals being returned for resubmission.
4. No substituted equipment shall be reviewed without prior approval in accordance with the requirements of "substitutions" under Division 1 specification section.
5. Mark the submittals, "SUBMITTED UNDER SECTION_____".

    a. Submittals shall be marked to show specification reference including the section and paragraph numbers.

6. The Contractor shall schedule submittals in order to maintain the project schedule. For coordination requirements refer to Division 01 Specification Sections, which outline basic submittal requirements and coordination. All Division 01 Specification Sections requirements shall be used in conjunction with this specification section.
7. Prior to any submission the contractor shall be responsible for performing the following quality control items to ensure compliance with all project requirements:

    a. Review all Shop Drawings and Product Data
    b. Review all field measurement criteria.
    c. Review all field construction criteria and methodologies.
    d. Review all catalog numbers and similar data.
    e. Review all coordination requirements of affected trades.
    f. Review conformance to all appropriate specification sections.

8. All drawings shall be prepared using latest version of AutoCAD®, drawn accurately, and in accordance with the CAD Standards "CAD Standard Application Guide". The Contractor shall not reproduce the Contract Documents or copy standard information as the basis of the technical data, hand drawn mark-ups of the original project drawings shall not be acceptable. Failure to provide a complete set of "contractor prepared" installation drawings at the time of submittal shall result in all submittals being returned for resubmission.
9. The ESSI shall have a registered RCDD professional review and seal all system designs, installations and testing certification for all electronic security systems and associated structured cabling. Failure to provide RCDD sealed shop drawings shall result in all shop drawings being returned for resubmission without any reviews taking place.
10. The Design Professional's review of shop drawings and/or samples does not relieve the Contractor from compliance with all requirements of the project documents. No deviations from the project requirements shall be accepted unless the Contractor has informed the Owner and Design Professional in writing of any such deviations prior to the submission of

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shop drawings, has noted all deviations on the shop drawing submission, and the Owner and Design Professional has given written approval for the specific deviations to the project documents, otherwise all project requirements shall stand. The Owner and Design Professional's review does not relieve the Contractor from any responsibility for delivering all criteria as stipulated by the contract documents because of errors, lack of clarity or omissions on the part of the Contractor in the review of shop drawings and/or samples by the Design Professional.

11. Submit all system testing and startup procedures to be employed. Include all estimated times for performance of all tests, all test equipment and manpower necessary for testing.
12. Submit all integrator qualifications, certifications and licenses in accordance with the requirements as specified elsewhere in this specification section.
13. Submit project schedule outlining the time frames for all equipment with long lead times for equipment deliveries; include all system commissioning, testing and training time expectations. Project schedule shall be submitted as CPM schedule and shall utilize a software based project management program.

B. Shop Drawings:

1. All shop drawings shall include sufficient information, clearly presented, to determine full compliance with all project drawings and specifications. Include the following information for review, failure to provide all information listed below shall result in all shop drawing submittals being returned for resubmission:

   a. All Building Floor and Site Plans
   b. All equipment with manufacturer's name(s), model numbers,
   c. All equipment /device electrical ratings and power requirements
   d. All equipment /device performance ratings.
   e. All standby battery and wiring voltage drop calculations
   f. All surge and\or transient protection devices and device locations
   g. All equipment rack, panels and cabinet layouts, rack/cabinet sizes.
   h. All equipment and device-mounting elevations.
   i. All device wiring details.
   j. Complete point-to-point-wiring diagrams for all systems. Include all equipment and wiring termination schedules and programming matrixes.

2. Provide a complete set of "contractor prepared" installation drawings. All drawings at the minimum shall consist of floor plans indicating all device locations, device identifications, control panels, auxiliary control panels, power supplies, annunciation panels, conduit and cabling requirements as well as all 120 volt electrical circuit locations and designations.

   a. Drawings shall include at the minimum the following:

      1) Detailed equipment layouts for all equipment rooms. Coordinate all room layouts with affected trades.
      2) Floor plan drawings showing locations of all control panels, sub-panels, ancillary controls, equipment cabinets and/or racks, annunciator panels, HMI terminals, auxiliary power supplies, devices and sensors, electrical power and grounding terminations as well as all device\sensor identifications
      3) Conduit routing of all conduits 2 inches in diameter or greater.
      4) System riser diagrams and single line drawings representing interconnections of all system control panels, sub- panels, ancillary controls,

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equipment cabinets and/or racks, annunciator panels, HMI terminals, auxiliary power supplies, devices, sensors and components, include all cable types and sizes, electrical power connections and circuits, grounding connections, surge and\or transient protection devices and all field device\sensor identifications.

5) Block diagrams and Logic flow charts representing all systems architecture and interconnection of the security management systems (SMS) and fire management systems (FMS) all related integrated subsystems. Include detailed information on all system component integrations, data transmission and media conversions as well as logical functional data and performance criteria.
6) Equipment wattage for all equipment room locations and estimated BTU production.
7) Detailed equipment layouts for all equipment consoles. Indicate all equipment locations, power connections and installation details. All equipment mounting hardware/brackets and installation details, Identify type size, load capacities of all mounting hardware/brackets; include all mounting and installation details, all space requirements, any special architectural modifications required.
8) Outline drawings of all equipment cabinets/racks showing the relative position of all major components, all-wiring and grounding terminations. Include all panel, cabinet and/or rack dimensions.
9) Door Schedules for each door equipped with electronic security components. At a minimum, the door schedules shall be coordinated with Division 08 work and include the following information:

   a) Door Number (Extracted from Architectural Drawings)
   b) Door location on security floor plan drawing
   c) Installation Details
   d) Door Description (Extracted from alarm programming matrixes)
   e) Data Gathering Panel Input Number
   f) Door Position or Monitoring Device Type & Model Number
   g) Lock Type, Model Number & Power Input/Draw (standby/active)
   h) Card Reader Type & Model Number
   i) Shunting Device Type & Model Number
   j) Sounder Type & Model Number
   k) Delayed Egress Type & Model Number
   l) Intercom (video or standard)
   m) Camera ID# associated with camera call-up (Extracted from alarm programming matrixes)
   n) Type of Electric Transfer Hinge
   o) Electric Pass-through device
   p) Remarks Column for Camera

10) Camera Schedules for all interior and exterior cameras. Note: camera schedule shall be coordinated with the Owner and Design Professional for determination of camera numbers and naming conventions. At a minimum, the camera schedules shall include the following information:

    a) Camera Number
    b) Camera Naming Convention

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c) Description of Camera Coverage
d) Camera Location description
e) Camera location on Floor Plan drawings (include sheet and grid number)
f) Camera Type & Model Number
g) Mounting Type & Model Number
h) Installation Details
i) Cable Sizes, Types, Conductors, and Color
j) Power Input & Current Draw
k) Power Supply Location and electrical circuit number
l) Automatic Camera Call input (Extracted from alarm programming matrixes)
m) Remarks Column for Camera

3. All shop drawing submissions shall have a registered RCDD professional review and seal all shop drawings confirming that the proposed cabling infrastructures and terminations are in conformance with all stipulated standards and requirements as herein specified or in related specification sections.
4. Failure to provide all required documentation in accordance will ALL related specification requirements at the time of shop drawing submission shall result in all submittals to be returned for non- compliance to the contract requirements.

C. Equipment Submittals and Data Sheets:

1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.

   a. Include all equipment data sheets pertinent to equipment provided. All data sheets shall be highlighted indicating specific equipment supplied. Failure to provide the proper annotation of all equipment shall result in submittals being returned for resubmission.

2. Submit complete technical data necessary to evaluate the material and equipment. Include a complete technical specification for the submitted equipment, noting differences and adherence to this Section. Failure to provide the required data will result in all submittals being returned for resubmission.
3. Submit performance data, equipment ratings, cable requirements, control sequences, GUI based control panels, programming matrixes, logic diagrams and all other descriptive data necessary to describe the installation and operations of the system being provided. Failure to provide the required data will result in all submittals being returned for resubmission.
4. Provide a complete termination schedule of all system devices, sensors, components, equipment and controls, identify all locations as indicated on the installation drawings, include all unique identification numbers which correspond with shop drawing floor plans.

   a. Include point to point wiring terminations and programming matrixes for all readers and devices
   b. All Documentation shall be provided in current version Microsoft Excel spreadsheets

5. Provide a clear and concise sequence of operation that gives, in detail, all information required to properly operate all equipment and systems. Include detailed programming matrixes, indicating at the minimum all manual and automatic functions for all system,

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components and devices comprising the system being provided.

6. Provide copies of all preliminary graphic screens for all HMI configurations for this project. Graphic maps shall indicate all site plans, floor plan maps, utility screens, camera/monitor interface screens all door control functions, intercom activation's, alarm indications, door interlock functions and ancillary controls.
7. Provide a listing of all recommended time zone and alarm shunting functions.
8. Provide a preliminary list of all on screen emergency response instructions and help menus.
9. Provide system parts list which shall include those replacement parts recommended by the equipment manufacturer, quantity of parts, current price and availability of each part.
10. Failure to provide all required documentation in accordance will ALL related specification requirements at the time of shop drawing submission shall result in all submittals to be returned for non- compliance to the contract requirements.

D. Maintenance and Operation Manuals: Submit in accordance with all requirements of Division 01 specification sections and as herein specified.

1. Maintenance and Operation Manuals shall be submitted for all systems and equipment specified in the technical sections. Furnish the number of copies as specified by Division 1, all manuals shall be bound in hardback binders, (manufacturer's standard binders) or an approved equivalent prior to the commissioning, testing and final acceptance of each system.

   a. The Contractor shall also furnish one complete set of manuals as specified herein at the time of shop drawing submission for Design Professional s' use in the review of all submittals.

2. Inscribe the following identification on the cover: "Maintenance and Operational Manual" include the name and location of the system, equipment, building, name of Contractor, and contract number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the system or equipment.

   a. The Maintenance and Operation Manuals at the minimum shall include:

      1) Copy of approved shop drawing and equipment submittals
      2) Internal and interconnecting wiring and control diagrams
      3) with data to explain detailed operation and control of all equipment, components, devices and servers.
      4) A complete control sequence describing start-up, operation, and shutdown of all equipment, components, devices and servers.
      5) Description of the function of each principal item of equipment.
      6) Installation and maintenance instructions

         a) Safety precautions
         b) Diagrams and illustrations.
         c) Testing methods.
         d) Performance data.
         e) Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare parts, and name of servicing organization.

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f) Appendix; list qualified permanent servicing organizations for support of the equipment, including addresses and certified qualifications.

b. Failure to provide all required documentation in accordance will ALL related specification requirements at the time of shop drawing submission shall result in all submittals to be returned for non-compliance to the contract requirements.

1.5 QUALITY ASSURANCE

A. In addition to all general provisions of the Contract, including but not limited to all; General and Supplementary Conditions, Division 01 Specification Sections include the following project requirements:

1. Integrator Qualifications: The projects' Electronic Security System Integrator (ESSI) shall be an accredited and authorized distributor of the appropriate equipment manufacturer and shall be fully certified in the installation, testing and programming of all equipment being provided. The ESSI shall be a licensed security Contractor with a minimum of five (5) years' experience installing and servicing systems of similar scope and complexity.

a. The ESS integrator shall be capable of providing documented successful work experience of at least three (3) facilities of equivalent size and technical requirements utilizing the proposed equipment being provided. The system integrator shall have on staff a minimum of one full time individual that holds a current RCDD registration.

1) All electronic security systems and related work shall be certified in writing to the Owner and Design Professional by a RCDD professional asserting that all electronic security system shop drawings and all associated structured cabling is in conformance with all appropriate NEC requirements, EIA/TIA standards; NFPA 731 recommended practices, BICSI recognized installation practices and all related specification sections.

2. Cable Installer Qualifications: The cable installation contractor shall demonstrate not less than three (3) years' experience in the installation of structured cabling systems and shall have on staff a minimum of one full time member that holds a current BICSI level II installer credential.

a. NOTE: The installation of all cabling shall be under the direct supervision of a current BICSI level II installer who shall be knowledgeable in the following technical applications:

1) The Routing and installation of shielded, unshielded, twisted pair, coaxial and fiber optic cables.
2) Generally accepted industry standards, as well as manufacturers written installation instructions, will be used for in-process quality control and final acceptance of the work installation.

b. Provide registration number and expiration date of BICSI level II installer assigned to the project.

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3. The Owner and Design Professional reserve the right to require the Contractor to submit a list of installations where the products have been in operation before approval of shop drawings.

   a. Experience shall be defined as the completion of the specific system being provided, with that system being successfully operated by the Owner for its intended purpose for at least three (3) years.
   b. In addition to the above "Experience" shall also be defined as the completion of modifications and renovations to any associated system being provided in any existing occupied facility of this size and magnitude.
   c. For each facility submit the following:

      1) Name and location of facility.
      2) Date of Occupancy or beneficial use by Owner.
      3) Owner's representative to contact and telephone number.
      4) Construction Manager or General Contractor.
      5) Project Architect or Engineer.
      6) Provide detailed information on the installed locations with operational equipment.

4. Service Qualifications: The ESSI shall be a permanent service organization maintained and/or trained by the product manufacturer on the products being provided for this project.

   a. The integrator shall be properly licensed by the governing municipality (where required) certified to provide the services and work of the specific system being provided.
   b. In addition, all integrators shall be capable of providing full service for the entire warranty period within an 8-hour response time upon notification of a service emergency.
   c. Provide registration number and expiration date of RCDD professional.

5. Manufacturers Qualifications: The manufacturer shall regularly and presently produce, as one of the manufacturer's principal products, the equipment and materials specified for this project, and shall have manufactured the items for at least three years.

   a. Product Qualification: The Manufacturer's product shall have been in satisfactory operation, on three installations of similar size and type as this project, for approximately three years.
   b. The equipment manufacturer shall submit the appropriate documentation certifying that the project integrator is a qualified service provider and certified in the installation and programming of all manufacturers' products being provided for this project.

1.6 RECORD DOCUMENTS

A. In addition to all general provisions of the Contract, including but not limited to all; General and Supplementary Conditions, Division 01 Specification Sections include the following project requirements.

   1. Provide complete set of finalized copies of record documents prior to final acceptance of the project by Owner and Design Professional in accordance with all requirements of Division 01 specification sections. At the minimum the record documents shall contain

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all information, data and drawings as described in Chapter 1.4 "Submittals" of this specification section.

a. As-built documents shall be submitted in both paper and electronic media formats in the quantities as specified by Division 1 specification requirements.

1) All electronic record drawings shall be prepared and submitted utilizing an AutoCAD based program as manufactured by Autodesk. Where electronic documents are prepared using other than an AutoCAD program manufactured by Autodesk, the contractor shall provide to the Owner and Design Professional the necessary software to electronically view the submitted documents.
2) All electronic data sheets, control sequences, programming matrixes and other descriptive data shall be provided in PDF format.
3) Copies of all current system programming and associated software shall be provided on downloadable media formatted for the use in restoration all system operations and functionality in the event of a catastrophic failure.

1.7 SOFTWARE AGREEMENT

A. Included as part of the scope of work for this project the Owner shall retain the ownership and access rights of ALL system programs and software associated with all systems installed and/or modified as part of this project.

1. The contractor shall provide to Owner complete copies of all current software programming and software licenses related to the operation of each system prior to final acceptance of the related Contract scopes of work.

a. All programming shall include but not be limited to all device identifications, device descriptions, Programming Logic Matrixes, all program access level passwords as well as all function and sub-function routines.

2. Programming and software copies shall be provided to the Owner on CD or DVD digital formatted media. In addition, the contractor shall provide a complete hard copy printout of all system programming and shall be included as part of closeout documentation for review by the Owner and Design Professional.

B. Software and firmware upgrade provisions shall be included as part of this specification requirement and shall include the automatic upgrades as required to maintain all software and firmware to the manufacturers most current revision on all system components installed and or modified as part of this project for duration of the warranty period. This upgrade policy shall require the contractor to install, test and certify all software and firmware upgrades that become available from manufacturer for a period of one year from date of final acceptance to the expiration of the warranty.

1. Upgrading of software shall include all revised/new software, labor, testing certification as well as all licenses, software and all programming copies as described in Chapter 1.6 of this section associated with the installation of all revised software.
2. These updates shall be accomplished in a timely manner, fully coordinated with the system operators, and incorporated into the operations\maintenance and software documentation manuals.

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a. One (1) scheduled final update shall be provided near the end of the warranty period, at which time the Contractor shall install and validate the latest released version of the Manufacturer's software and firmware for all systems installed and\or modified for this project.
b. All software changes shall be recorded in a log maintained in the unit control. An electronic copy of the most current software update shall be maintained within the log.

1) At a minimum, the contractor shall provide a description of the modification, when the modification occurred, and name and contact information of the individual performing the modification. The log shall be maintained in a white 3 ring binder and the cover marked "Software Change Log".

3. Provide not less than thirty days' notice to the Owner and Design Professional to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

1.8 EXTRA MATERIAL

A. In addition to all general provisions of the Contract, including but not limited to all; General and Supplementary Conditions, Division 01 Specification Sections refer to related specification sections "Extra Material" for specific requirements.

B. All Extra materials shall be provided at the time of final acceptance of the project and a signed packing list shall be obtained at the time of delivery. At no time is the contractor to use the extra materials provided for this project to replace malfunctioning or damaged equipment and or components.

C. Provide 5% of all material as " Extra Material."

PART 2 – PRODUCTS

2. 1 MANUFACTURED PRODUCTS

A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, that meet and/or exceed the specified performance and features of the equipment and/or systems and for which replacement parts shall be readily available to the system integrator and/or using agency.

1. When more than one unit, device or component of the same class of equipment is required, such units, devices or components shall be the product of a single manufacturer.
2. Acceptable manufacturers for each system shall be as specified and shall be provided in full compliance with the requirements of this and all related specification sections and contract drawings.

a. Manufacturers listed as acceptable shall not negate the contractors' responsibility for providing all equipment, devices, components and/or

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systems, in accordance with all functions and performance requirements of the Contract Documents.

b. Where manufacturer and/or manufacturer model numbers reference specific system components in the related specification sections, it is to establish the performance requirements and quality of the systems and components only.

1) It is in no way an inference that the referenced model numbers are the manufacturer's current product and are the only acceptable components for this project unless specifically referenced as "no substitutions".

c. The Contractor shall provide the manufacturers' most current product that shall meet and/or exceed the specified performance and features of the equipment and/or systems.

d. Equivalent UL- listed equipment may be substituted for the approved manufacturers unless stipulated by other specification sections as "No Substitutions". All substitutions shall be submitted for approval by Owner and Design Professional in accordance with all requirements of Division 01 specification sections and Chapter 1.4 "Submittals" of this specification section.

1) Where systems and/or components are referenced as "no substitutions" the specific system and/or components shall be provided.

2) All substitutions shall comply with all requirements as specified above and all system performance standards shall be maintained.

3) The contractor shall stipulate the following information impacted by such a substitution.

a) Any and all extensions in time impacted by the substitution.
b) Any changes to the architectural or structural elements to the project
c) Differences in operation and/or performance from intended system criteria.

4) Failure to provide the required substitution information shall result in "without consideration" the immediate rejection of the substituted equipment and/or systems.

B. Equipment Assemblies and Components:

1. Components of an assembled unit need not be products of the same manufacturer.

a. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.
b. Components shall be compatible with each other and with the total assembly for the intended service.
c. Constituent parts which are similar shall be the product of a single manufacturer.
d. Factory wiring shall be identified on the equipment being furnished and on all wiring diagrams.

C. Where Factory or Off-Premises Testing of any equipment, product or assembly is recommended by the product manufacturer or where specified as part of this section and/or any related specification section:

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1. The Owner and/or Owner representatives shall have the option of witnessing all factory tests. The Contractor shall notify the Design Professional at a minimum of thirty (30) working days prior to the performance of any factory or off-premises tests.

    a. Where the factory or assembly point for all off-premises testing is not within two (2) hours driving time from the project location, the ESSI shall include as part of this project all per diem costs (travel, meals and lodging) for a minimum of two representatives of the using agency and the project Design Professional to witness all testing.

2. Provide four (4) copies of certified test reports containing all preliminary test data and testing procedures shall be furnished to the Owner and Design Professional prior to any final testing and not more than ninety (90) days after completion of any tests.
3. When equipment, product or assembly fails to meet any factory or off-premises tests, retesting of equipment, product or assembly shall be mandated, the manufacturer/integrator shall be liable for all additional expenses, including all expenses incurred by the Owner and Design Professional for witnessing the retesting of any equipment, product or assembly.

PART 3 – EXECUTION

3.1 EQUIPMENT PROTECTION

A. Protect all materials, equipment, devices or components permanently installed and/or stored on the job site. Protect all materials, equipment, cabling, devices or components during construction and after installation, provide appropriate protection of all materials, equipment, components and/or devices until time of substantial completion. All materials, equipment, components and/or devices shall be protected during shipment and storage against any physical damage, dirt, moisture, cold, snow or rain:

1. During installation, enclosures, equipment, controls, controllers, circuit protective devices, and other like items, shall be protected against entry of any foreign matter; and shall be vacuum cleaned both inside and outside before testing and operating and repainting if required.
2. Any materials, equipment, components and/or devices, stored on site which have been deemed by the Design Professional to exhibit any indications of damage or exposure dust or moisture shall not be installed and shall returned to the source of supply for immediate replacement.

    a. The use of spare parts or the return of defective equipment for repair to mitigate the damage of defective materials, equipment, components and/or devices shall not be acceptable. All materials, equipment, components and/or devices shall be new and unused until final acceptance by the Design Professional.

3. Provide and apply protective material immediately upon receiving the products and maintain throughout the construction process.

    a. Painted surfaces shall be protected with factory installed removable heavy kraft paper, sheet vinyl or equal.
    b. Any damaged paint on equipment and materials shall be refinished with the same

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quality of paint and workmanship as used by the manufacturer so repaired areas is not obvious or detectable.

4. Failure to properly protect all materials, equipment, components and/or devices prior to final acceptance shall constitute sufficient cause for rejection of materials, equipment, components and/or devices should any defects, damage or degradation in performance is observed.

B. Immediately replace all malfunctioning materials, equipment, components and/or devices with new unused products up until the time the Design Professional issues final acceptance of the system. The returning of any malfunctioning equipment, devices and/or components to the manufacturer for repair and then reinstallation at the project site shall not be acceptable.

1. All replacement materials, equipment, components and/or devices shall be factory new and not scavenged from the Project's spare parts inventory or factory recycled products unless expressly identified by contractor prior to replacement and approved beforehand by the Design Professional.

3.2 WORK PERFORMANCE

A. Installation, final termination, testing, start-up and commissioning of all systems, system components and cabling infrastructures shall be under the direct supervision of the appropriate system integrator. The integrator shall be an accredited and authorized distributor of the appropriate equipment manufacturer and shall be fully certified in the installation, testing, commissioning and programming of all equipment, devices, components and/or systems being provided as part of this project.

B. Job site safety and worker safety is the responsibility of the contractor. Ensure that safe access and egress from all work areas is maintained during movement and installation of materials. Clean up all debris generated by installation activities. Keep all security electronic equipment rooms free of debris at all times.

C. Pre-installation Conferences: Include provisions to attend all pre- installation conferences at Project site in compliance with all requirements in Division 01 specification section and as herein specified. Review methods and procedures related to installation and operations of all safety and security systems, including, but not limited to, the following:

1. Inspect and discuss electrical and control system roughing-in related to all safety and security systems as well as other preparatory work required to be performed by other trades.
2. Review sequence of operations for each type of system, controls and/or integration to any systems and/or equipment provided by other trades
3. Review and finalize construction schedule and verify availability of materials, installation personnel, equipment, and any preparatory work by other trades needed to make progress and avoid delays.
4. Review required start-up, testing, commissioning and certifying procedures to be employed for each system and any impacts to other trades.

D. For work on existing facilities, arrange, phase and perform work to assure the operation of all security systems for other buildings and contiguous spaces at all times. Refer to Division 1 specification section for additional information.

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E. All new work shall be installed and connected to existing work neatly and carefully. Disturbed or damaged work shall be replaced or repaired to its prior conditions, as required by Division 1 specification sections.

F. Coordinate the installation of all cabling, conduits/raceways and cable trays and equipment with applicable trades to ensure proper operation and function of all integrated systems in accordance with all related specification sections. Refer to Division 1 specification section for additional project coordination requirements.

1. Coordinate with all trades at the time of shop drawing submission detailing all space and/or room conditions. The contractor shall coordinate with the appropriate trade all conditions impacting the installation of any system including but not limited to all equipment locations, ceilings, lighting fixtures, fire protection piping and ductwork layouts to the satisfaction of all concerned trades, subject to final review by the Design Professional.

a. Coordinate exact location of all desktop/counter/wall mounted equipment with the Owner and Design Professional and affected trades prior to the installation of any equipment and/or cabling.
b. Coordinate exact location(s) of all ceiling mounted cable, conduits, equipment and/or devices with all architectural plans, reflected ceiling plans and affected trades prior to installation.
c. Equipment installations requiring coordination with other trades the contractor shall provide all templates, back-boxes and equipment anchor bolts for mounting or flush mounting preparation, (e.g. pedestals or other devices requiring mounting on walls, concrete pads or other materials). Coordinate delivery of templates and equipment anchor bolts to preclude any delay in the construction schedule or the work of the affected trade.
d. If installation of equipment, devices, cabling, raceways, cable trays and/or conduit is performed prior to coordination with other trades, which interferes with work of other trades or operation and maintenance of the facility, make necessary changes to correct the condition at no additional cost to the Owner.
e. Prior to the final programming of any systems review with Owner and Design Professional all system features, functions, system operations, network mapping, system integrated responses and all related programming as required for the proper operation of the respective security systems.

G. The Contractor shall maintain a complete set of current and up to date set of shop drawings and equipment submissions at the job site at all times. The Shop drawings and all other submissions shall be marked up to reflect all as-built conditions and shall be made available for review by the Design Professional at request.

3.3 EQUIPMENT/CABLE INSTALLATION AND REQUIREMENTS

A. All system wiring and equipment installation shall be in accordance with good engineering practices and by all IEEE, TIA, NEC and manufacturer's requirements. Wiring shall comply with all state and local electrical codes. All wiring shall test free from all grounds, shorts, stray voltages and EMI.

B. Follow manufacturers' instructions for installing, components and adjusting all equipment and cabling. Submit two (2) copies of such instructions to the Design Professional before installing any equipment. Provide a copy of such instructions at the equipment during any work on the

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equipment. Where no instructions are included with the equipment, follow accepted industry practices and workmanlike installation standards.

C. Ensure that all security and video, systems cabling supports (conduits, support grips, cable tray and J-hooks) are fully installed before proceeding with cable installation. At no times shall any cables be installed and left unsupported. At no times shall cables be tie- wrapped to any other supporting structure in lieu of specified cable supports. Do not bundle or tie-wrap the cables even within the approved cable supports.

1. Do not leave any system cabling unprotected on the floor at any time. If cables must be left on any floor, protect the cables so that they may not be walked on or have any material or equipment placed or rolled on top. Replace all damaged cables from demarcation to termination point; no splicing of damaged cables shall be permitted.
2. Maintain manufacturers recommended minimum bend radiuses of all cabling. Do not stretch, stress, tightly coil, bend or crimp the backbone, horizontal, patch or workstation cables. The Contractor shall keep all cabling out of the way of other trades during staging of any work. The contractor at the contractor's expense will replace all severely stressed or damaged cables, equipment and materials as determined by the Design Professional.

D. Equipment location shall be as close as practical to locations as indicated on the contract drawings.

1. Provide all equipment clearances in accordance with NEC requirements. Arrange equipment to facilitate unrestricted access for maintenance and service around all equipment, components and/or cable terminations.

E. Inaccessible Equipment:

1. Where the Design Professional determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the project.

a. "Conveniently accessible" is defined as being capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit and raceways.

F. Cabling Requirements

1. Contractors shall have the option to combine all home runs and conductors of same type and voltage "class" in accordance with NEC requirements unless specified elsewhere. Size all conduits and install all conductors in accordance with NEC requirements and manufacturers recommendations.

a. All TCP/IP based security system cabling is to be Category-6 and concealed above suspended ceilings, bundled and supported to the building structure. All cabling bundles shall be plenum rated and shall not contain any AC carrying conductors or non- associated security network cables. All TCP/IP based security cabling located above accessible suspended ceilings may be installed without conduit and shall be

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supported by "J" hooks.

1) Cabling installed above inaccessible ceiling spaces shall be installed in dedicated conduits.
2) No exposed cabling will be acceptable in finished or occupied spaces of the facility without approval by the Owner and Design Professional.
3) Any CCTV, intercom or PACS system cabling installed exterior to the building and/or all cabling being routed from the facility to any remote location external to the project location shall be installed in fiber optic cable.
4) Refer to related specification sections for additional information for additional information related to cabling types, sizes and testing requirements.

G. Environmental Conditions

1. Systems, components, devices materials and equipment shall be capable of withstanding the environmental conditions of the space without mechanical or electrical damage or degradation of operating capabilities or performance.

a. Interior, Controlled Environment: System components, installed in temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of 2 to 50 deg C (36 to 122 deg F) dry bulb and 20 to 90 percent relative humidity, non-condensing and shall utilize NEMA 250, Type 1 enclosures.
b. Interior, Uncontrolled Environment: System components installed in non-temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of -18 to 50 deg C (0 to 122 deg F) dry bulb and 20 to 90 percent relative humidity, non-condensing and shall utilize NEMA 250, Type 4X enclosures.
c. Exterior Environment: System components, conduits and back- boxes installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of -34 to 50 deg C (-30 to 122 deg F) dry bulb and 20 to 90 percent relative humidity, condensing. Rated for continuous operation where exposed to rain as specified in NEMA 250, winds up to 137 km/h (85 mph) and snow cover up to 610 mm (24 in) thick shall utilize NEMA 250, Type 4X enclosures.
d. Hazardous Environment: System components, conduits and back-boxes located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
e. Corrosive Environment: System components, conduits and back-boxes subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, shall utilize NEMA 250, Type 4X enclosures.
f. Submersible Environment: System components, conduits and back- boxes subjected to prolonged submersion in water, shall utilize NEMA 250, Type 6P enclosures.
g. Areas where equipment and devices may be subject to damage by the general population shall be installed in vandal resistant enclosures, all fire alarm devices shall be provided with wire guards.
h. Console: All console equipment shall, unless noted otherwise, be rated for continuous operation under ambient environmental conditions of 15.6 to 29.4 deg C (60 to 85 deg F) and a relative humidity of 20 to 80 percent.

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H. Conduits/raceway/Cable Trays:

1. All conduits/raceways shall be concealed and shall be installed above accessible finished ceilings and/or in walls. Any conduits/raceways installed in areas requiring installation to be exposed, shall be installed tight to ceilings at right angles to walls and shall not obstruct any access hatches, equipment service panels, lighting or other equipment and/or devices. No exposed conduits/raceways shall be installed without prior approval of the Design Professional prior to installation.

   a. All raceways shall be supported in accordance with NEC requirements and shall be affixed in such a manner that tampering and/or removal by the general population without the use of specialized tools shall be prevented.

   b. Outlet Boxes: shall be 4 x4 x 2-1/8 inches deep for all data jack locations and single gang for wall mounted telephone locations.

      1) All outlet boxes shall be provided with single or dual gang device mud-rings flush to finished wall as required based on type and configuration of outlet and type of wall construction.
      2) Use deep masonry boxes at masonry construction. T-Bar hangers or other appropriate mounting hardware shall be utilized to support boxes mounted in the ceiling.

I. Penetrations of Walls and Floors

1. All wall/floor penetrations are to be sleeved and fire stopped with approved fire stopping material. Coordinate all cable and conduit penetrations of the structure with all trades.

   a. All penetrations of walls and floors shall be fire stopped in accordance with the ASTM and NFPA standards. Refer to related specification sections for additional information.
   b. Floor penetrations shall be sleeved with a minimum sleeve diameter of 4 inches. An additional penetration shall be provided for future use, sleeved and capped and fire stopped as required.
   c. Coordinate size of wall penetration with conduit size, number of conductors. Comply with all NEC requirements.
   d. The fire rating of all penetrated walls, floors, and ceiling structures shall be strictly maintained. All penetrations shall be fire-stopped and sealed by the Contractor.
   e. Install fire-stopping in open penetrations and in the annular space of penetrations for fire rated barriers.
   f. Installation of fire-stops shall be performed by an applicator/installer qualified and trained by the manufacturer. Installation shall be performed in strict accordance with manufacturer's detailed installation procedures.
   g. Installation of all fire-stopping shall be in accordance with fire test reports, fire resistance requirements, acceptable sample installations, manufacturer's recommendations, local fire and building authorities, and applicable codes and shall be installed in a manner acceptable to the authority having jurisdiction.

J. Transient Voltage Surge Suppression: All cables and conductors extending beyond building façade, except fiber optic cables, which serve as communications, control, or signal lines shall be protected against Transient Voltage surges and have Transient Voltage Surge

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Suppression (TVSS) protection.

1. The TVSS device shall be UL listed in accordance with Standard TIA 497B installed at each end. Lighting and surge suppression shall be a multi-strike variety and include a fault indicator.
2. Protection shall be furnished at the equipment and additional triple solid state surge protectors rated for the application on each wire line circuit shall be installed within 914.4 mm (3 ft) of the building cable entrance. Fuses shall not be acceptable for surge protection applications. All inputs and outputs shall be tested in both normal mode and common mode to verify there is no interference at the minimum surge suppression test shall meet the following criteria.

    a. All system power supplies serving exterior system components or devices shall be provided with the appropriate transient surge suppression protection on both the line side as well as the load side.

        1) A 10-microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes shall be the minimum performance requirements. Provide surge suppression in accordance with all manufacturers requirements.
        2) An 8-microsecond rise time by 20-microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes shall be the minimum performance requirements. Provide surge suppression in accordance with all manufacturers requirements.
        3) Maximum series current: 2 AMPS. Provide units manufactured by Advanced Protection Technologies, model #TE/FA 10B or TE/FA 20B or approved equal.
        4) Operating Temperature and Humidity: -40 to 85 deg C (-40 to 185 deg) shall be the minimum performance requirements. Provide surge suppression in accordance with all manufacturers requirements.

3.4 GROUNDING AND BONDING

A. All electronic equipment, conduits, cable trays, racks/cabinets and cable shields shall be properly grounded and bonded in accordance with all requirements of TIA 607-D, NEC 250 and IEEE 1100.

1. All grounding connections shall provide the equalization of all grounding potentials between the building power system and the grounding terminations at the security equipment in order to provide the diversion of electrical transients as well as providing the necessary coupling in order to cancel and/or reduce any voltage transients.

    a. Equipment Grounding: Metallic structures, equipment racks, cabinets and enclosures as well as all raceways, cable trays, junction boxes, outlet boxes, machine frames, and other conductive items shall be bonded and grounded.

2. All connections of grounding conductors to ground rods, bus bars, rebar, structural members, pipes and fences, as well as splices of any ground conductors, shall be made by exothermic welds except where otherwise noted. All connections to bar lugs shall be exothermic weld or compression type connections. Bolted type connection of ground conductors may only be made where terminal lugs or blocks have been furnished and

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installed in equipment by the manufacturer.

a. Equipment grounding conductors shall be insulated stranded copper, except for sizes No. 10 AWG and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes No. 4 AWG and larger shall be permitted to be identified per the NEC.
   1) At the minimum bonding connection shall be a #6 AWG copper conductor. All grounding shall provide an effective bonding connection between the protected equipment to the nearest approved building grounding electrode (structural steel) as well as to the local power distribution panel grounding system (e.g., ac branch circuit panel board's equipment grounding busbar). All bonding and grounding connections shall be NEMA type compression or exothermic welded connections.

3. Refer to related specification sections for any additional grounding and bonding requirements.

3.5 EQUIPMENT IDENTIFICATION

A. Identify all system controls, components and equipment cabinets using plastic laminate engraved labels, or approved equal. Firmly affix to the panel, device and/or component.

1. Nameplates shall be laminated black phenolic resin with a white core with engraved lettering, a minimum of 6 mm (1/4 inch) high. Secure nameplates with screws. Nameplates that are furnished by manufacturer as a standard catalog item or where other method of identification is herein specified. Dymo or Kroy tap adhesive backed lettering shall not be acceptable.
2. Color-code all junction boxes and enclosures per NEC recommendations. At the minimum provide all security junction boxes as follows:

   a. Color for Security circuits - Orange.
   b. Color for CCTV circuits - Green
   c. Color for Fire - Red.
   d. Letter all pull boxes and junction boxes located in service area tunnels, above accessible ceilings and pipe chases with laminated black phenolic resin with a white core with engraved lettering, a minimum of 6 mm (1/4 inch) high. Secure nameplates with screws.
      1) Example: Security system "SS," Circuit Number SS-126.
      Engraved laminated plastic tags shall be used for identification and securely fastened in accordance with the project requirements.

3. Permanently label all wiring at both ends with self-adhering plastic labels.
4. Provide typewritten circuit directories installed in 3-ring binders with transparent page protectors in each control and sub control cabinet and/or equipment rack.

3.6 MAINTENANCE & SERVICE

A. General Requirements

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1. The Contractor shall provide all services required and equipment necessary to maintain the electronic security systems in an operational state as specified after formal written acceptance of the system.

    a. Provide all necessary material required for performing scheduled adjustments or other non-scheduled work. Impacts on facility operations shall be minimized when performing scheduled adjustments or other non-scheduled work. Refer to Division 1 specification section for additional information.
    b. The adjustment and repair of the security systems shall include all software and firmware up-dates on all computers, CPU's, HMI terminals, devices, communications and data transmission medias' (DTM), facility interface processors, signal transmission equipment, video surveillance and security management software and processors.
    c. Test, inspect and service each system on a quarterly basis at three month intervals during the warranty period from the time of final acceptance. The contractor shall compare each three month test results with the test results at the time of final acceptance.

        1) The contractor shall include as part of the quarterly test the calibration and/or adjustment of any device, component and/or system that has deviated from the original test results at the time of final acceptance.

    d. For each quarterly maintenance period, provide written notification to the Owner of the systems condition before and after service, the exact components that were tested and serviced, and overall status of the system.

B. Personnel

1. Service personnel shall be manufacturer certified in the maintenance, testing and repair of the type of system and equipment provided for the project. Provide the Owner and Design Professional the name of the designated service representative, and of any change in personnel. The Owner and Design Professional shall be provided copies of system manufacturer certification for the designated service representative.

    a. Schedule of work to be performed during regular working hours, Monday through Friday, excluding federal holidays.

C. Emergency Service

1. The Owner shall initiate service calls whenever the system is not functioning properly. The Contractor shall provide the Owner with an emergency service center telephone number. The emergency service center shall be staffed 24 hours a day 365 days a year. The Owner shall have sole authority for determining catastrophic and non-catastrophic system failures.

    a. For catastrophic system failures, the Contractor shall provide same day eight (8) hour service response with a defect correction time not to exceed sixteen (16) hours from [notification] [arrival on site]. Catastrophic system failures are defined as any system failure that the Owner determines will place the facility(s) at increased risk.

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b. For non-catastrophic failures, the Contractor within 1 business day with a defect correction time not to exceed 48 hours from time of notification.

D. Records & Logs

1. The Contractor shall maintain records and logs of each task and organize cumulative records for each component and for the complete system chronologically. A continuous log shall be submitted for all devices. The log shall contain all initial settings, calibration, repair, and programming data. Complete logs shall be maintained and available for inspection on site, demonstrating planned and systematic adjustments and repairs have been accomplished for the system.

E. Work Request

1. The Contractor shall separately record each service call request, as received. The record shall include the serial number identifying the component involved, its location, date and time the call was received, specific nature of trouble, names of service personnel assigned to the task, instructions describing the action taken, the amount and nature of the materials used, and the date and time of commencement and completion. The Contractor shall deliver a record of the work performed within five (5) working days after the work was completed.

F. System Modifications

1. The Contractor shall make any recommendations for system modification in writing to the Design Professional. No system modifications, including operating parameters and control settings, shall be made without prior written approval from the Design Professional. Any modifications made to the system shall be incorporated into the operation and maintenance manuals and all related documentation.

3.7 WARRANTY

A. Warrant material and workmanship for a period as specified in Division 1 of the contract documents and all related specification sections. The warranty period shall commence from the date the Contactor received written notification of final acceptance from the Design Professional. At the minimum the contractor shall provide warranty provisions:

1. Warrant the replacement of defective components/materials and/or correct defective work when given notice by the Owner during the warranty period.
2. Warranty excludes liability for consequential incidental, or special damages due to vandalism, misuse, or acts of God.
3. Onsite warranty response time by qualified technician shall be within 8 hours upon receipt of request from Owner.
4. Warranty repairs shall be provided to the Owner at no cost. This shall include but not limited to all repairs and/or replacement of defective components/materials, all labor charges, all travel costs and all vehicle charges.
5. Response time shall be 7 days a week / 24 hours a day / 365 days a year.
6. Provide test, inspection and service of each system on a quarterly basis at three month intervals.
7. Contractor must provide verification that they maintain their principal base of operation along with the personnel that will be responsible for providing service within

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3 hours driving time to the project site. This tenet of the warranty shall remain in effect for the life of the warranty.

8. All TCP/IP based security communications cabling and related appurtenances shall be provided with the manufacturers 25 year extended warranty in addition to all requirements above.

B. The Contractor shall, as a condition of final payment, execute a written warranty certifying all contract requirements have been completed according to all requirements of the Contract Documents.

1. All system testing, commissioning, demonstration and training shall be performed prior to final system acceptance. All defects or damages due to faulty materials or workmanship shall be repaired or replaced without delay, to the satisfaction of the Owner and Design Professional, at the Contractor's expense.

a. The contractor shall provide written documentation of test results and stating what was done to correct any deficiencies. The first inspection shall occur 90 calendar days after the acceptance date. The last inspection shall occur 30 calendar days prior to the end of the warranty.

b. The warranty period shall be extended until the last inspection and associated corrective actions are complete. When equipment and labor covered by the Contractor's warranty, or by a manufacturer's warranty, have been replaced or restored because of its failure during the warranty period, the warranty period for any replaced or repaired equipment or restored work shall be reinstated for a period equal to the original warranty period, and commencing with the date of completion of the replacement or restoration work.

2. In the event any manufacturer customarily provides a warranty period greater than one (1) year, the Contractor's warranty shall be for the same duration for that component.

3.8 FIELD SERVICES

A. Notify Owner and Design Professional in writing, ten days advance of testing of all system cabling to prevent delays in construction schedules.

1. Test all cabling to confirm that no grounds, shorts, sneak currents, RFI and EMI conditions exist prior to start-up and commissioning of all, components, devices, equipment and/or systems.

a. Before requesting a final inspection, the Contractor shall perform a series of end to end installation performance tests. The Contractor shall submit for approval by Design Professional all test procedures to be employed, test result forms, and timetable for testing all fiber optic and copper plant wiring.

b. Acceptance of the simple test procedures discussed below is predicated on the Contractor's use of the recommended products including but not limited to twisted pair cable, cross-connect blocks, and outlet devices specified and adherence to the inspection requirements and practices set forth. Acceptance of the completed installation will be evaluated in the context of each of these factors.

2. Perform all tests, as required, by authorities having jurisdiction throughout the facility.

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3. Testing of all electronic security systems shall be in the presence of the Owner and Design Professional as well as all appropriate representatives of the authorities having jurisdiction.

    a. All completed the security systems shall be fully tested in accordance with all requirements of NFPA 731. Upon completion of a successful testing, the contractor shall so certify in writing to the Owner and Design Professional that all testing was completed, certified and left in first class operational condition, include all completed NFPA 731 certification and test reports.
    b. The service of a competent, factory-trained engineer or technician authorized by the equipment manufacturer shall be provided to technically supervise installation and participate during initial system programming, start-up, final testing, assist in the final acceptance testing and Owner demonstrations.
    c. At the minimum all acceptance testing, demonstrations and training shall include, but not be limited to the following:

        1) Security Monitoring/Control Systems
        2) CCTV Surveillance System Performance and Functions
        3) Remote Security Monitoring/Control Systems
        4) CCTV Surveillance System programming and configurations
        5) UPS and Battery Back-up Functions.
        6) Integration of all Auxiliary Systems

4. In addition, provide all testing, commissioning and certifications as specified by Division 1 specification sections and any manufacturer's recommendations or requirements.

B. Training

1. In addition to all demonstration and training as specified by Division 1 specification section and all related Division 28 specification sections, system demonstrations and training shall be provided in accordance with all requirements of this section.
2. Prior to acceptance of the work, the System Integrator shall demonstrate to the Owner and Design Professional, all systems and sub-systems all features and functions of each system and shall instruct the Owner Representatives in the proper operation, event sequences, programming and maintenance of all systems and sub-systems.
3. The System Integrator shall furnish the necessary trained personnel to perform all demonstrations and instructions and arrange to have the manufacturer's representatives present to assist with the demonstrations.
4. Training time shall include, as a minimum, the total time determined by the sum of the times per system as specified in this and related specification sections, for performing the prescribed demonstrations/training. Refer to related specification sections for additional training requirements.

    a. Allow a minimum of 16 hours' time for each system provided for performing the prescribed demonstrations/training.

        1) Provide a minimum of (4) four 4-hour training classes performed at the project location and spaced over a three week interval. Training classes shall be scheduled not less than 48 hours apart to allow the Owner User\Operators to familiarize themselves with all system operations.

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5. Provide operation, parts and maintenance manuals defining operation and troubleshooting methods of all systems and review with Owner User\Operators as part of training demonstrations.
6. Provide detailed video recordings in high quality digitally formatted media of all demonstration and training of all systems and system operations.

    a. Utilize remote microphones as may be required to ensure high quality audio of the recorded demonstrations.
    b. Permanently and professionally label all recorded materials and provide self-sealing plastic cases.

C. Inspections

1. At the completion of the project and prior to final acceptance of the Work, provide evidence of final inspections and approvals to the Owner and Design Professional, as required by the authorities having jurisdiction as well as all requirements of Division 01 specification sections.

END OF SECTION 28 05 00

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SECTION 28 13 00

ACCESS CONTROL

PART 1 - GENERAL

1.1 STIPULATIONS

A. Project drawings and general provisions of the Contract, including but not limited to all; General and Supplementary Conditions, Division 01 Specification Sections and all stipulated Specification Sections shall apply to this and all related Division 27 specification sections.

B. Related Sections:

1. Division 07 – Through-penetration Firestop Systems
2. Division 26 – Common Work Results for Electrical
3. Division 26 – Low Voltage Electrical Power Conductors and Cables
4. Division 26 – Grounding and Bonding for Electrical Systems
5. Division 26 – Hangers and Supports for Electrical Systems
6. Division 26 – Raceways and Boxes for Electrical Systems
7. Division 26 – Identification for Electrical Systems
8. Division 27 – Common Work Elements for Communications Systems
9. Division 27 – Network Communications Systems
10. Division 27 – Network Hardware
11. Division 27 – Two-Way Communications System
12. Division 27 – Audiovisual Systems
13. Division 28 – Common Work Elements for Electronic Safety and Security
14. Division 28 – Access Control
15. Division 28 – Video Surveillance System

C. Reference Symbols:

1. All device symbols are defined by the appropriate symbol schedules. Because of the scale of the drawings, symbols are shown on drawings as close as possible to the mounting location.

    a. Contractor shall coordinate exact locations with all architectural drawings, site plans, reflected ceiling plans, furniture plans, mechanical and electrical drawings as well as all affected trades prior to submittal of any shop drawings.

D. Abbreviations:

1. Refer to Specification Section 28 05 00 for additional information.

E. Definitions:

1. Refer to Specification Section 28 05 00 for additional information.

1.2 SUMMARY

A. Section Includes:

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1. The Security Systems Contractor shall include in the bid all labor, materials, tools, plant, transportation, storage costs, software/licenses, installation, programming, configuration, testing, commissioning, training, equipment, insurance, temporary protection, permits, fire stopping, inspections, taxes and all necessary and related items required to provide complete and operational equipment / systems shown and described in this section.
2. This section is intended to define and describe minimum security system performance, required vendors and equipment, and installation standards and criteria.
3. All equipment and materials provided shall be new and unused and of the most current model or revision. All components of this system shall be installed in a workmanlike manner, following security industry "best practices" and in strict adherence to the manufacturer's specifications and applicable codes.
4. All Security System design guides, schematic designs, design development documents, device location maps, system records, record documents, operating instructions, and emergency response procedures are extremely confidential. Access to these documents shall be restricted to authorized personnel, the Security System Contractor(s), and approved vendors providing associated services. Parties receiving these documents shall take every reasonable precaution to protect these documents from unauthorized access.
5. Failure to follow manufacturer guidelines or the substitution of non-approved equipment or materials shall result in the rejection of the installation and shall require remediation efforts.
6. The Security Contractor shall furnish and install all equipment, accessories and materials in accordance with these specifications and drawings to provide a complete and operating security access and surveillance system.
7. Any material and/or equipment necessary for the proper operation of the surveillance system not specified or described herein shall be deemed part of this specification.
8. Final approval and acceptance of the installed systems rests solely with the Owner's Facility and Security personnel.

1.3 DESCRIPTION OF WORK

A. Provide all labor, materials, equipment, services and accessories necessary to furnish and install the work of this Section, complete and functional, as indicated in the contract documents and as specified herein.

B. The following standards, requirements, and equipment access control and video management systems shall be provided:

1. Networked nodes and panels, configured with the appropriate access, alarm input, and temperature probe application blades.
2. Lock power supplies, 24VDC, with fused protected outputs.
3. Systems controller with partitioning feature.
4. Integration with the building's fire alarm system to release fail-safe locks upon activation of the fire detection system.
5. Doors identified on the drawings as an access control portal shall include at least one card reader, electric door hardware (furnished and installed by others), and door status switch as described elsewhere in this document. Additional components, including external request-to-exit devices and push-to-exit emergency buttons, may also be required for specific applications.

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6. The networked access control panels and power supplies shall be wall mounted in the designated MDF and IDF Room locations shown on the drawings. Each networked access control panel and power supplies will require the following:

   a. Minimum of one dedicated 120V, 20A power circuit hard-wired into the panel.
   b. (1) Ethernet connection for each Network Node.
   c. Fire alarm relay panel for lock power control

7. Security Contractor shall provide and install individual patch cables between the Data Outlet and the Network Node. Coordinate with Telecommunications contractor. Data outlet shall be installed inside Network Node panel enclosure.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Submittals shall include information that confirms compliance with contract requirements. Include the manufacturer's name, model numbers, technical data sheets, and shop drawings as required.

C. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings and other data necessary for the Owner and Engineer to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify equipment being submitted.

D. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams
2. System labeling schedules.
3. Cable administration drawings.
4. Battery and charger calculations for central station, workstations, and controllers.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section "Operation and Maintenance Data," include the following:

1. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files of the hard-copy submittal.
2. System installation and setup guides with data forms to plan and record options and setup decisions. Submit manufacturer's operation and maintenance data, customized to the specified systems installed. Include system and operator manuals. Training of staff on hardware and software functions.

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3. Maintenance Service Agreement: Submit a sample copy of the manufacturer's maintenance service agreement, including cost and services for a one-year period for Owner's review.

B. Record Drawings: During construction maintain record drawings indicating location of equipment and wiring. Submit an electronic version of record drawings for the specified systems no later than Substantial Completion of the project. Project record drawings shall accurately show the physical placement of the following:

1. Equipment and devices.
2. Interfaces to fire alarm system and other external systems.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70, National Electrical Code; SIA CP-01, and SIA CP-07.

C. The Contractor shall be responsible for providing, installing, and configuring the access control and video surveillance systems as shown. The Contractor shall also provide certification as required.

D. The access control and video surveillance systems will be installed and tested to ensure all components are fully compatible as a system and can be integrated with all associated security subsystems.

E. Manufacturers Qualifications: The manufacturer shall regularly and presently produce, as one of the manufacturer's principal products, the equipment and material specified for this project, and shall have manufactured the item for at least three years.

F. Product Qualifications:

1. Manufacturer's product shall have been in satisfactory operation, on three installations of similar size and type as this project, for approximately three years.
2. The Owner reserves the right to require the Contractor to submit a list of installations where the products have been in operation before approval.

G. Contractor Qualifications:

1. The Security Contractor shall be a licensed Security Contractor with a minimum of five (5) years' experience installing and servicing systems of similar scope and complexity.
2. The Contractor shall be an authorized regional representative of the system approved for installation. The Contractor shall provide four (4) current references from clients with systems of similar scope and complexity which became operational in the past three (3) years. At least three (3) of the references shall be utilizing the same system components, in a similar configuration as the proposed system. The references must include a current point of contact, company or agency name, address, telephone number, complete system description, date of completion, and approximate cost of the project.

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3. The owner reserves the option to visit the reference sites, with the site owner's permission and representative, to verify the quality of installation and the references' level of satisfaction with the system.
4. The Contractor shall provide copies of system manufacturer certification for all technicians. The Contractor shall only utilize factory-trained technicians to install, program, and service the specified systems. The Contractor shall only utilize factory-trained technicians to install, terminate and service controller/field panels and reader modules.
5. The technicians shall have a minimum of five (5) continuous years of technical experience in electronic security systems. The Contractor shall have a local service facility.
6. The facility shall be located within 60 miles of the project site. The local facility shall include sufficient spare parts inventory to support the service requirements associated with this contract. The facility shall also include appropriate diagnostic equipment to perform diagnostic procedures.

H. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within four hours of receipt of notification that service is needed.

I. Pre-installation Conference: Conduct conference at project site.

1.8 PROJECT CONDITIONS

A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 36 to 122-degree F dry bulb and 20 to 90 percent relative humidity, non-condensing.
2. Indoor, Uncontrolled Environment: NEMA 250, enclosures. System components installed in non-temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 0 to 122-degree F dry bulb and 20 to 90 percent relative humidity, non-condensing.

1.9 LINE ITEM PRICING

A. Provide unit price and extended price for each line of material.

B. Provide a separate line item for labor, permit fees, taxes and subcontractor mark-up.

1.10 WARRANTY

A. Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.

B. Warranty Period: One year from date of final walk-through and sign-off by the Owner.

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PART 2 - PRODUCTS

2.1 DESCRIPTION:

A. Security Access System: Subject to compliance with requirements, provide product indicated on Drawings. The access control system for this location shall be an extension of the existing Honeywell system.

2.2 ACCESS CONTROL EQUIPMENT

A. Network Nodes, Door interface Panels and Input/Output Panels

1. Honeywell Pro-Watch

B. All power supplies shall be – Altronix AL600 with PD16 for panels and devices (12VDC) or ACM8 for locks (24VDC) or approved equals

C. Card Readers:

1. All readers shall be Bluetooth enabled.
2. Provide mullion readers for mullion installations.
3. All readers shall communication with access control panels via OSDP.
4. HID MultiClass or approved equal

2.3 PUSH-BUTTON SWITCHES

A. Push-Button Switches:

1. Momentary-contact mushroom-type push buttons with stainless-steel switch enclosures.
2. Single gang, with “PUSH TO EXIT” knob, Green in color.
3. Push-button switches shall be powered from their associated controller, using DC power.
4. Push-button switches shall be equipped with an adjustable 1 to 45 second pneumatic time delay.

B. Mounts

1. Flush or surface mounting.
2. Push buttons shall be suitable for flush mounting in the switch enclosures.
3. Enclosures shall additionally be suitable for installation in a controlled and uncontrolled indoor environment.

C. Manufacturer: Dortronics 5236 Series or approved equal.

2.4 DOOR HARDWARE INTERFACES

A. Electrified Door Hardware:

1. The Door Hardware Contractor shall be responsible for furnishing and installation of electrified door hardware. Refer to the architectural door and door hardware schedule for additional information and coordination
2. Locksets and exit devices shall have built-in request-to-exit switches.

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3. The Security Contractor shall be responsible for connecting the electrified door hardware to the access control system.
4. Power for the electrified door hardware and electromagnetic locks shall be provided by a 24VDC power supply that is furnished and installed by the Security Contractor.
5. All electric hardware installations shall comply with the appropriate requirements of national, State, and local building codes and ordinances, and with requirements for access-controlled doors in a means of egress.

B. Where required by code or local ordinance, electric door hardware shall be interfaced with local fire alarm and fire protection systems and provided with dedicated push-to-exit emergency release devices.

C. Door Contacts:

1. Door contacts shall be capable of detecting a 1" separating movement between magnet and switch housing. Upon detection, the door contact shall transmit an alarm signal to the security management system.
2. Door monitored switches shall be SPST recessed type unless otherwise specified.
3. Manufacturer: Interlogix 1078 concealed; 2505A Surface and 2207A-H Overhead Door
4. The color of the switch shall match the color of the door frame as closely as possible.
5. Surface mounted door monitored switches shall have an anodized alloy housing with stainless steel armored cable. Surface mounted switches shall be

D. External Passive Infrared (PIR) Request-to-Exit Devices:

1. Designed for use with surface-mounted magnetic locks.
2. Wall or ceiling mount, with adjustable field pattern. Exact location will depend on existing conditions and required coverage area. Unless noted otherwise on drawings, conceal wireways and junction box.
3. RTE sensor shall be installed to provide positive detection of a person approaching the door to exit. The sensor should be installed to minimize unwanted detection in halls, corridors, rooms, etc.
4. Manufacturer: Bosch DS-150i series. Light gray or black color to match adjacent finishes.

E. Panic Devices

1. Designed to support alarm message requirements to the Security Desk via push-button.
2. Connected to Access Control System.
3. Manufacturer: Under-Desk-Mounted: HUB2SA by United Security Products.

2.5 FIRE ALARM INTERFACE:

A. The Fire Alarm Contractor shall provide two (2) fire alarm relays in MDF and each IDF Room. The relay shall be mounted near the access control system power supply and Network Node enclosures.

B. The Security Contactor shall provide an interconnection between the fire alarm relay and each door power supply. The purpose of the interconnection is drop power to all fail-safe locks upon activation of the fire detection system.

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C. The Security Contractor shall provide an interconnection between the fire alarm relay and each Network Node. The purpose of the interconnection is to provide an alarm input to the Network Node for mustering purposes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.

B. Examine roughing-in for conduits and pathways for access control cabling and conduit at PCs, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Comply with recommendations in SIA CP-01 and CP-07.

B. Comply with ANSI/TIA 606-C, "Administration Standard for Commercial Telecommunications Infrastructure."

C. Obtain detailed project planning forms from manufacturer of access-control system; develop custom forms to suit Project. Fill in all data available from Project plans and specifications and publish as Project planning documents for review and approval.

1. Record setup data for control station and workstations.
2. For each Location, record setup of controller features and access requirements.
3. Propose start and stop times for time zones and holidays and match up access levels for doors.
4. Set up groups, facility codes, linking, and list inputs and outputs for each controller.
5. Assign action message names and compose messages.
6. Set up alarms. Establish interlocks between alarms, intruder detection, and video surveillance features.
7. Prepare and install alarm graphic maps.
8. Develop user-defined fields.
9. Develop screen layout formats.
10. Propose setups for guard tours and key control.
11. Discuss badge layout options; design badges.
12. Complete system diagnostics and operation verification.
13. Prepare a specific plan for system testing, startup, and demonstration.
14. Develop acceptance test concept and, on approval, develop specifics of the test.

D. In meetings with Architect and Owner, present project planning documents and review, adjust, and prepare final setup documents. Use final documents to set up system software.

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3.3 INSTALLATION REQUIREMENTS

A. Security Systems Contractor shall execute their work in a neat and skillful manner.

B. The Security Systems Contractor shall provide all wiring, connectors, power supplies, interfaces, and other hardware as necessary to affect an operating system unless specified as being provided by others in the contract drawings and documents.

C. Wiring and cabling shall be in conduit where exposed to physical damage or tampering. Method and routing of any exposed raceways and/or wiring shall be approved by the owner prior to installation.

1. Cable that is concealed within building structure or above suspended ceilings shall not require conduit.
2. Cable that is not accessible due to location or which is installed at or below the roof deck must be attached to the building structure or structural steel using approved hangers, straps, or other suitable methods. Cables shall not rest directly upon structural steel members or suspended ceiling assemblies.

D. System components and control devices shall be wired to the appropriate power supply, Network Node, and PoE switch as homeruns. Terminations shall be made in a manner consistent with the equipment manufacturer's written installation instructions.

E. Conductors and cables shall be specified and sized to reduce voltage drop and ensure proper system operation.

1. Data communications wiring between the Network Node and the access control door shall be 4-element composite security cable with an overall jacket.

F. All cable shall be labeled at origin and termination, referencing to a master legend schedule shown on submittal drawings. Labeling and any splice locations shall be noted on Record Drawings.

G. Security contractor shall provide trim plates, adapters or back boxes for card readers as needed to mount to electrical back boxes. The color and finish of all trim plates, adapters or back boxes used shall closely match that of the card reader.

H. Completely seal all exterior openings of outdoor mounted devices and back boxes to make weather-tight.

I. Request-to-Exit (RTE) sensor housings shall compliment wall and door frame on which the RTE sensor is being installed. Provide trim place to enable mounting of RTE sensor to a single-gang junction box (mounted horizontally).

1. Trim plate shall completely cover rough-in opening.
2. Trim plate color and finish shall match RTE sensor.

J. Miscellaneous hardware required for installation shall be suitable for the purpose for which it is used. Hardware includes nuts, bolts, screws, washers, miscellaneous fasteners, terminals, terminal strips, tie wraps, and related parts. Where the equipment manufacturer specifies hardware for use in the installation, the hardware specified shall be used. The finish on all

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hardware and fasteners shall be suitable for the environment in which it will be used and shall be selected to minimize corrosion or deterioration due to moisture, sunlight, or temperature extremes.

K. All electrical power work and conduit work shall be by licensed electricians.

L. The Security Systems Contractor will be required to install and test local equipment, programming it with an IP address specified by the Owner. In all circumstances, the Security Systems Contractor's work shall not be considered complete until the equipment has been programmed and tested to the satisfaction of the Owner.

3.4 CABLING

A. Comply with NECA 1, "Good Workmanship in Electrical Construction."

B. Furnish and install cables and wiring in accordance with these specifications and the requirements in Section 280513 "Conductors and Cables for Electronic Safety and Security."

C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

D. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use UL-listed plenum-rated cable in environmental airspaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.

E. Boxes and enclosures containing security-system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered accessible.

F. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.

G. Furnish and install end-of-line resistors at the field device location, not at the controller or panel location.

3.5 CABLE INSTALLATION

A. Comply with ANSI/TIA-569-E, "Commercial Building Standard for Telecommunications Pathways and Spaces."

B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.

C. TIA 232-F Cabling: Cabling between devices shall not exceed 50 feet, or distance allowed by equipment manufacturer.

D. Card Readers, Keypads, Door Contacts, and Request-to-Exit Devices:

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1. Install number of conductor pairs recommended by manufacturer for the functions specified.
2. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.

E. Install minimum No. 18 AWG cable from controller to electrically powered locks. Do not exceed 500 ft.

F. Install minimum No. 18 AWG AC power wire from transformer to controller, with a maximum distance of 25 ft.

3.6 GROUNDING

A. Comply with Division 26 "Grounding and Bonding for Electronic Safety and Security."

B. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."

C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

D. Bond shields and drain conductors to ground at only one point in each circuit.

E. Signal Ground:

1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
2. Bus: Mount on wall of main equipment room with standoff insulators.
3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

3.7 INSTALLATION

A. Furnish and install card readers, keypads, magnetic locks, push buttons, door contacts, and request-to-exit devices. Provide connectivity to these devices if these devices have been furnished as part of the door hardware.

3.8 IDENTIFICATION

A. In addition to requirements in this article, comply with applicable requirements in Section 260553 "Identification for Electrical Systems" and with ANSI/TIA-606C.

B. Develop and provide as-built device and cable administration drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.

C. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

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1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.

D. At completion, as-built drawings and information provided by the contractor shall reflect as-built conditions.

3.9 SYSTEM SOFTWARE AND HARDWARE

A. Configure and test software and hardware and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power-supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.
3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.

B. Devices and circuits will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.11 STARTUP SERVICE

A. Engage a factory-authorized service representative to supervise and assist with startup service.

1. Complete installation and startup checklists according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

B. Train Owner's maintenance personnel on equipment operation, startup and shutdown, troubleshooting, servicing and preventative maintenance procedures. Review the data contained in the Operating and Maintenance Manuals with Owner's personnel. Training shall occur separate from startup activities. Provide 4 hours of training minimum.

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3.12 PROTECTION

A. Maintain strict security during the installation of equipment and software. Rooms housing the control stations and workstations that have been powered up shall be locked and secured with an activated security system reporting to a central station complying with UL 1610, "Central-Station Burglar-Alarm Units", during periods when a qualified operator in the employ of Contractor is not present.

3.13 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain security access system.

B. Develop separate training modules for the following:

1. Computer system administration personnel to manage and repair the LAN and databases and to update and maintain software.
2. Operators who prepare and input credentials to man the control station and workstations and to enroll personnel.
3. Security personnel.
4. Hardware maintenance personnel.
5. Corporate management.

3.14 FINAL ACCEPTANCE

A. After work is completed, and prior to requesting the Final Acceptance Test, Security Contractor shall conduct a final inspection and pre-test all equipment and system features. Contractor shall correct any deficiencies discovered as the result of the inspection and pre-test.

B. Contractor shall notify Owner and Engineer to schedule a Final Acceptance Test. The request for Acceptance Test shall constitute a certification from the Security Contractor that all work is complete and in compliance with the Contractor Documents, all systems have been tested, and all corrections have been made.

C. Technicians performing the acceptance test shall have been involved in the installation of the system and shall be thoroughly familiar with all aspects of the work.

D. Security Contractor shall provide all ladders, tools, test equipment as needed to accomplish the Final Acceptance Test.

E. Any portions of the work found to be deficient or not in compliance with the Contract Documents will be rejected.

END OF SECTION 28 13 00

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SECTION 28 20 00

SECURITY COMMUNICATION SYSTEM

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

B. The work to be done under this section of the specifications shall include the furnishing of labor, material, equipment, and tools required for the complete installation of the work indicated on the drawings, as specified herein, or as noted in other related sections.

C. Related Sections:
1. Division 07 – Through-penetration Firestop Systems
2. Division 26 – Common Work Results for Electrical
3. Division 26 – Low Voltage Electrical Power Conductors and Cables
4. Division 26 – Grounding and Bonding for Electrical Systems
5. Division 26 – Hangers and Supports for Electrical Systems
6. Division 26 – Raceways and Boxes for Electrical Systems
7. Division 26 – Identification for Electrical Systems
8. Division 27 – General Requirements for Telecommunications
9. Division 27 – Common Work Elements for Communications Systems
10. Division 27 – Network Communications Systems
11. Division 27 – Two-Way Communications System
12. Division 27 – Audiovisual Systems
13. Division 27 – Nurse Call/Code Blue
14. Division 28 – Common Work Elements for Electronic Safety and Security
15. Division 28 – Physical Electronic Safety and Security
16. Division 28 – Video Surveillance System

D. Reference Symbols:

1. All device symbols are defined by the appropriate symbol schedules. Because of the scale of the drawings, symbols are shown on drawings as close as possible to the mounting location.

   a. Contractor shall coordinate exact locations with all architectural drawings, site plans, reflected ceiling plans, furniture plans, mechanical and electrical drawings as well as all affected trades prior to submittal of any shop drawings.

D. Abbreviations:

1. Refer to Specification Section 27 05 00 for additional information.

E. Definitions:

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1. Refer to Specification Section 27 05 00 for additional information.

1.2 WORK INCLUDED

A. This Section describes the IP-based security communication system, including installation of all intercom field devices, master stations, controllers, enclosures, towers, stanchions, power supplies, wiring, conduit systems, software and all other required appurtenances for a complete working system.
   1. The system as described shall be installed, tested, and delivered in working condition. The system will include all required hardware, software, programming and wiring to accomplish the requirements of the specification and contract drawings.
   2. All materials furnished will be new and of the latest design available from a manufacturer who is engaged in the manufacture and sale of digital communication systems. The manufacturer shall have an installed base of similar systems as a reference.
   3. While the contract documents identify the location and quantities of equipment for estimating purposes, the installation of all wiring (power, network, audio, video, and control), field devices, and equipment shall be based on the complete vendor's/manufacturer's wiring diagrams and equipment layouts as approved for this project. The Contractor, prior to installation, shall submit the pre-construction design shop drawings for approval.

B. The Contractor shall coordinate all system operational requirements and integration with all other security systems.

C. The Contractor shall provide a complete system design based on the requirements as set forth in the contract documents. Provide integration with the access control system, and video surveillance system.

D. The IP-based system shall leverage the facility IT (Ethernet) network infrastructure for system communications as required to support security system. The Contractor shall provide all network requirements to the Owner’s IT Department prior to final acceptance testing.

1.3 SCOPE OF WORK

A. The scope of work to be included in this contract does not necessarily include every item of work. The Contractor shall supply and install items that meet the specified requirements of the construction documents. The Security Communication System (SCS) shall be furnished complete, installed, tested, and operational.

B. Scope of work shall include the Campus site and parking lot Security Communication Systems, including all intercoms and stanchions, with access to audio paging, the SIP based VoIP telephone system, integration with CCTV systems, alarm systems and access control security systems as shown on the plans.

C. Furnish and install a complete microprocessor controlled, "duplex" voice communication system as described herein and shown on the plans. The system shall include an IP based central audio server(s) and include all necessary boards, power supplies, master control stations, substations, receptacles, special mounting boxes, loudspeakers, terminal boards, cable, connectors, and accessories for a complete operational communication system.

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D. Scope of work shall also include all building code required elevator lobby and stairwell two-way communications including all code-compliant cabling and connections to the Hospital IT and Telephone System required to communicate with the 24-hour monitored response station.

E. The work to be provided, in addition to furnishing and installing the SCS, shall include the following:
   1. Provide all pre-construction shop drawings as required by the General Requirements section.
   2. Coordinate all stanchion and tower locations with Owner, Landscape and Architect prior to rough-in of any back-boxes and conduits.
   3. Provide software that meets specified contract requirements.
   4. Installation, set-up, and programming of SCS server, if applicable, and any related ancillary equipment.
   5. Verification that proposed equipment and devices furnished are adequate and well suited for the intended purpose.
   6. Perform a layout check to ensure that adequate access is available for construction, installation, and maintenance of equipment and devices furnished; however, the Contractor is not responsible for furniture.
   7. Participate and preform acceptance testing to ensure system has been properly installed and that it meets the specifications and all applicable codes.
   8. SCS system administration will be by end-user. The System Administrator shall be responsible to configure and maintain the system after system acceptance. System utilities shall be provided for the System Administrator to use. Software for database backups and file maintenance shall also be provided.

1.4 RELATED WORK

A. Systems shall be installed by a qualified Security Contractor, who shall coordinate all work with other contractors and trades.

B. All necessary conduit, raceways, pull boxes, standard boxes, (and special boxes provided by intercom manufacturer), shall be installed by the Electrical contractor.

1.5 SUBMITTALS

A. Refer to Specification Section 27 05 00 for additional information.

PART 2 - PRODUCTS

2.1 GENERAL

A. All products not provided by the Owner shall be new and unused, and shall be of manufacturers' current and standard production.

B. Where two or more equipment items of the same kind are provided, all shall be identical and provided by the same manufacturer.

C. Drawings and Specifications indicate major system components, and may not show every component, connector, module, or accessory that may be required to support the operation specified. Contractor shall provide all components needed for complete and satisfactory and intended operation.

D. Product Availability

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1. The Contractor, prior to submitting a proposal, shall determine product availability and delivery time, and shall include such considerations into his proposed Contract Time.
2. Certain products specified may only be available through factory authorized dealers and distributors. Contractor shall verify his ability to procure the products specified prior to submitting a proposal.

E. Systems Integration

1. The owner has an existing Honeywell Access Control System that shall be expanded into the new building. The contractor shall provide all remote wiring, software integration, configurations and any associated appurtenances required to control, monitor and audit door access at all access controlled door stations.
2. The owner has an existing ExacqVision video management system across the State. The contractor shall provide all remote wiring, software integrations, configurations and any associated appurtenances required to monitor all video door stations.
3. The contractor shall provide all remote wiring, software integration, licenses, configuration and any associated appurtenances required to trigger an event for camera call-ups for the following areas:
   a. Emergency Blue Light Stations
   b. Elevator Lobby Two-Way Intercom Stations
   c. Exterior video intercom door stations

2.2 APPROVED COMMUNICATION SYSTEM MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:

1. Basis of Design – Commend Concerto Series
   a. Approved equal

2.3 GENERAL DESCRIPTION

A. The audio video intercom system (“Intercom System”) shall be based upon a software-based intercom server. It shall be capable of managing up to 1,120 subscribers (endpoint devices) per VM. It shall support expansion with other Intercom Servers up to a total of 25,000 subscribers across the network environment.

B. The intercom server network shall have the capability to create a complete interconnected local or wide area network infrastructure including:

1. Compatible hardware-based intercom servers
2. VoIP, 2-wire digital, and 4-wire analog intercom (subscriber) stations
3. Desktop control stations
4. Alarm and activating devices via contact closures
5. Telephone handsets
6. SIP systems
7. Third-party radio systems
8. Public address systems

C. Supervision

NOT FOR BIDDING PURPOSES

1. The intercom system shall provide full autonomous supervision of head end, terminals speakers, microphones, master stations, and communications lines.
2. To ensure availability of intercom stations and loudspeakers, the intercom system shall have the capability for acoustic testing. A real-time audio test signal shall be sent on a schedule to a loudspeaker, analyzed by a microphone, whereupon the received signal is compared for fidelity.

D. In case of a device or network failure, the system or device shall be able to ensure uninterrupted operation by switching seamlessly to a backup device or Intercom Server.
1. Current operating data and the entire virtual machine shall be hot-transferrable to another data center without interrupting the running system.

E. Speech Communication - The intercom system shall provide for Full Duplex hands-free communication, allowing simultaneous talking and listening with echo cancellation.

F. The intercom system shall support broadcasts and multicast audio transmissions.

G. The intercom server network shall provide control and interconnection functions for the intercom system.

H. The intercom server shall be based on Linux (Debian) OS software for virtualized IT platforms.

I. The intercom server shall support the following types of devices:
1. SIP, IP, digital, analog and Intercom stations
2. Manufacturer's SIP terminals
3. Third-Party SIP telephones

J. Intercom terminals shall provide the means for a remote user to communicate with a system operator or other user of the intercom system.

K. The Contractor shall provide intercom terminals of the types and quantities listed in schedules and drawings.

L. All intercom terminals shall share the following common features:
1. The intercom terminal shall provide hands-free bi-directional audio communication, without requiring additional audio analytic server or special firmware.

2.4 VIDEO INTERCOM SERVER

A. General
1. The audio video intercom system ("intercom system") shall be based upon a software-based intercom server network capable of managing up to 112 subscribers per virtual machine (instance) 1,120 subscribers per server and a total of 25,000 subscribers across the network environment.
2. The intercom server network shall have the capability to create a complete interconnected local or wide area network infrastructure including:
a. compatible hardware-based intercom servers
b. IP, 2-wire digital, and 4-wire analog intercom (subscriber) stations
c. desktop control stations
d. alarm and activating devices via contact closures

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e. telephone hand sets

f. VoIP systems

g. third party radio systems

h. public address systems

3. Supervision

   a. The intercom system shall provide full autonomous supervision of head end, terminals speakers, microphones, master stations, and communications lines.

   b. To insure availability of intercom stations and loudspeakers, the intercom system shall have the capability for acoustic testing, where an audio test signal is sent to a loudspeaker, picked up and analyzed by a microphone, whereupon the received signal is compared with transmitted signal for fidelity.

4. In case of a system fault, the system shall be able to ensure uninterrupted operation by switching seamlessly to a backup data centre.

   a. Current operating data and the entire virtual machine shall be hot-transferrable to another data centre without interrupting the running system.

5. Speech Communication - The intercom system shall provide for full duplex hands-free communication, allowing simultaneous talking and listening with echo cancellation.

6. Audio Performance – Audio signals shall be processed and transmitted with 16 KHz message bandwidth to provide wideband voice level performance in the 50–7,000 Hz range.

   a. The intercom system shall support audio recording up to 100 simultaneous audio streams.

7. Pre-recorded content – The intercom system shall provide for the storage of pre-recorded music and message to be played constantly, upon schedule, or upon activation via event trigger or operator.

   a. Replay of pre-recorded content shall be configurable to multiple groups or zones.

8. Intelligent Volume Control - Intercom stations and loudspeakers shall be enabled to monitor background noise level and to adjust the station’s sound level accordingly.

9. The intercom system shall support broadcast and multicast audio transmission.

10. Audio Analytics – The intercom system shall support ambient noise analytics which constantly monitors the volume level of the background sound within the listening range of an intercom station and automatically opens a call connection if the sound volume level exceeds a defined threshold.

    a. The threshold level shall be adjustable based on time of day.

    b. Exceeding a defined threshold shall be considered as an alarm event type with the ability to trigger a defined response within the intercom system or an attached third-party system.

11. Alarms

    a. The intercom system shall be capable of receiving configurable alarms via input contacts or TCP/IP datagram messages.

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b. Upon receipt of any alarm it shall be possible to send alarm status message to designated control desks and initiate system events to include prerecorded message playback, control of output contacts, and email notification.

12. Video – The intercom system shall support bi-directional video transmission.
13. The Manufacturer shall offer as standard product the appropriate IP converters to allow the required field devices to operate seamlessly within the system.
14. The Manufacturer shall provide IP data and audio interfaces for connection of third party systems via licenses which are accessible and unlockable on line.
    a. Available system interfaces:
        1) control desk visualization
        2) video management systems
        3) access control systems
        4) analog and digital mobile radio
        5) public address systems
        6) mass notification
        7) emergency management
        8) audio recording
        9) VoIP
15. The intercom system shall provide for logging and reporting of all system events which can be accessed and compiled into custom reports by means of configurable data filters.

B. Intercom Server
1. The intercom server network shall provide control and interconnection functions for the intercom system.
2. The intercom server shall be based on Linux (Debian) OS software for virtualized IT platforms.
3. Coordinate with Owner for installation on vSphere by VMware, Hyper-V by Microsoft or XenServer by Citrix virtualization platform.
4. The intercom server shall support the following types of devices:
    a. IP, digital, analog and SIP Intercom stations
    b. Manufacturer's SIP terminals
    c. third party SIP telephones Non-SIP devices are supported through legacy servers or through the ET-901X IP interface for digital and analog intercom stations.
5. SIP
    a. The intercom server shall support the following:
        1) Up to 1,120 SIP subscribers per server
        2) Up to 32 calls between SIP subscribers per Instance
        3) Call features:

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a) Identification: calling line, connected line, calling name
b) Call waiting
c) Call hold
d) Multiple subscriber number
e) Direct dial-in
f) Call forwarding
g) Call deflection
h) Call transfer

4) Third party SIP based telephones shall be able to function as intercom terminals.

6. VoIP
   a. The intercom server shall support VoIP connectivity via SIP trunk to IP-PBX servers and service providers.
   b. The intercom server shall support VoIP connectivity to PSTN via SIP gateways.
7. Each server instance shall support up to 112 simultaneous subscriber conversations.
8. The intercom server shall be networkable via LAN or WAN with other virtual servers and Manufacturer's hardware servers.
   a. .NET connections shall be supported as required.
9. The intercom server shall be able to make a snapshot copy of the entire virtual machine at a specific point in time, including the operating system, and to restore the virtual machine from a snapshot.
10. Hardware requirements
    a. RAM: 1 GB for first instance; 256 MB for each additional instance
    b. CPU: 1 GHz per instance
    c. Storage: 30 GB minimum
11. Audio performance:
    a. Audio frequency range: 50-15000 Hz (–3 dB)
    b. Audio transfer bandwidth: 16 kHz
12. User interface
    a. Configuration – The user interface shall employ the concept of licensed virtual slots, whereby intercom functionality is provisioned via virtual cards occupying those licensed slots.
    b. The server software shall allow the monitoring of the state of each virtual card slot.
13. Server configuration and administration
    a. Server configuration properties shall include server identification, IP network address settings, intercom server network address settings, maximum bandwidth, and SIP subscriber parameters.

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b. The intercom server shall be capable of license administration, including activation and deactivation.

c. IP terminal configuration and current properties administered by the server shall include:

1) automatic definition of settings for multiple subscribers

2) device status

3) device – server connection status

4) IP network address settings

5) VLAN settings

6) QoS level

d. Intercom server settings shall be able to be saved or loaded in XML file format.

e. The intercom server shall be able to administer subscriber passwords.

f. Communications interface: IP or SIP trunk

14. Software clients – The intercom server shall support client interfaces for Windows-based PC's and Android and IOS-based smart phones.

15. Firewall – The server shall have the ability to control, allow or block selected traffic.

2.5 INTERCOM VIDEO MASTER STATIONS – TOUCH DISPLAY

A. General

1. The master station shall be an IP addressable hands-free or handset master station with a 5" touch display.

2. The master station shall be wall or desk mounted with the desk stand included.

3. The master station shall connect to the State IT network using Cat-6 or equal cable and be SIP compliant.

4. The master station shall offer line supervision and a scheduled device check of stations in its address book.

5. The master station shall have programmable speed dial buttons that can be used to call, page, monitor, or control a contact closure.

6. The master station can view a selected intercom's camera as well as an associated ONVIF Profile S camera by using the picture in picture function.

7. The master station shall have the ability to release the door that is associated with the station that it is communicating with. Stations can be called by using the directory or by direct dialing the stations number.

B. Technical Specifications

1. The master station shall have a 5" TFT color LCD touchscreen for both the handset and hands-free models.

2. The master station shall have a fixed color video camera with privacy shutter

3. The master station shall be SIP 2.0 compliant

4. The master station shall be ONVIF Profile S compliant

5. Multi-angled desk stand (30°, 45°, 60°)

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6. The master station shall have 2 contact outputs and 4 trigger inputs.
7. The master station shall include a base station that includes a handset.

C. Approved Manufacturer

1. Commend ID5 TD CM with desk kit (45°) and handset ID5 TD DKHS or approved equal.

2.6 EXTERIOR VIDEO INTERCOM DOOR STATIONS – TOUCH DISPLAY

A. General

1. The exterior video intercom door stations shall be weather resistant, (IP65) IP addressable video door stations.
2. The exterior video intercom door station shall be equipped with a 10.1" touch display (IPS-TFT) with 800 x 1280 pixel resolution.
3. They shall connect to the State IT and VoIP network using Cat-6 cable and be SIP compliant.
4. Each station shall be equipped with a megapixel fixed color camera.
   a. The camera angle shall be vertically adjusted using a lever on the back of the station.
   b. The video shall be capable of being streamed to existing State VMS using ONVIF Profile S or RTSP.
   c. Provide all licenses required to integrate the exterior video intercom door station with the State VMS.
5. The exterior video intercom door station shall be programmed to call up to 20 different stations with 3 different call level selections.
6. The stations shall have audible and visual indications for calling, communication, and door release.

B. Technical Specifications

1. The exterior video intercom door stations shall have a 600Ω output that can be used for paging or communication.
2. There shall be (2) contact outputs that can be programmed to trigger during door release.
3. There shall be (3) inputs that can be used to trigger an outgoing call or answer a call/page.
4. The exterior video intercom door station shall be SIP 2.0 compliant, capable of forwarding Caller-ID information.
5. Camera:
   a. Camera vertical adjustment +15º, 0º, or -8º (manual)
   b. ONVIF Profile S compliant
   c. 1/3" RGB CMOS 1280x960 pixel resolution

C. Approved Manufacturer

1. Commend OD1 or approved equal

2.7 INTERIOR/EXTERIOR VIDEO INTERCOM DOOR STATIONS (TYPE 2)

A. General

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1. The interior/exterior video intercom door station shall be a flush mount IP addressable video door station.
2. The video door station shall be equipped with either one or three programmable, backlit direct dialing buttons, as shown on the drawings.
3. The video door station shall connect to the State IT network using CAT 6 cable.
4. The video door stations shall have a built-in dry contact for door release (24V AC/DC, 500mA) and integrate into the State Access Control system.
5. The video intercom door station shall be equipped with an ONVIF Profile S compliant fixed camera with vertical angle adjustment.
6. The door stations shall call up to 20 different master stations with an additional 20 master stations capable using the contact input.
7. The speaker and microphone shall allow for two-way communication with the master station.

B. Technical Specifications

1. Power Source:
   a. 802.3af PoE compliant
2. Communication:
   a. Contact input for call-in
   b. Open voice hands-free
   c. 600 ohm line-out for paging or communication
3. Camera:
   a. Fixed color video camera
   b. ONVIF Profile S compliant
   c. 1/4” color CMOS Sensor
4. Outputs:
   a. 2 relay outputs (switch-over contacts) max. 60 VDC, 2A, 60 W.
5. Audio out:
   a. Line output for connection to loudspeaker module

C. Approved Manufacturer

1. WS 201P I CM or approved equal

2.8 INTERCOM VOICE SUBSTATIONS

A. General

1. The intercom voice substation shall be a surface mount IP addressable sub master station.
2. The voice sub master shall connect to the State IT network and VoIP system using Cat-6 cable and be SIP compliant.
3. Each voice station shall be programmed to call up to 20 different stations, there are 3 different call levels to choose from.

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4. The stations have audible and visual indications for calling, communication, and door release.

B. Technical Specifications

1. The station shall have an 8Ω, 2-watt output that can be used for paging or communication.
2. Communications:
   a. SIP 2.0 compliant
   b. Handset and hands-free communication
   c. Communication / call tone volume control switch
   d. Fully PoE powered
3. The station shall have (1) contact output that can be programmed to trigger during door release or based on the status of the station.
4. The station shall have (1) input that can be used to trigger an outgoing call or answer a call/page.
5. Sound files can be uploaded for custom messages to be played during certain functions (door release, call placed, communication start, error message).
6. Power Source:
   a. 1 PoE LAN port
   b. PoE (IEEE 802.3af class 0)
   c. Power Draw: 4.32 Watts
7. Approved Manufacturer
   a. Commend ES931H or approved equal

2.9 EMERGENCY CALL BOX STATIONS

A. General:

1. Blue Light Emergency Call Stations shall consist of an outdoor-rated vandal resistant ADA compliant hands free remote intercom call stations or telephones, a 360 degree multisensory CCTV IP camera and an emergency telephone tower, wall or pedestal mounting stanchions.
2. Remote call stations shall have full duplex two-way voice communications and calls shall be directed to a pre-programmed extension or master station using Caller-ID to identify the locations.
3. Emergency Call Boxes shall be housed in a National Electric Manufactures Association (NEMA) 250 Enclosure for Electrical Equipment compliant enclosures. Call-box enclosure shall include blue light/or similar strobe mounted behind or on top of the call box: A blue light or color lit strobe shall be activated (e.g. to inform others visually that assistance is required) when the emergency switch/button/phone is pressed/taken off-hook and shall flash for the duration of a call.
4. The faceplate shall be constantly lit by ultra-bright LEDs.
5. Enclosure and bracket system shall be designed to resist extreme weather conditions and constructed of weather resistant stainless steel.

B. Emergency Telephone:

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1. Emergency Telephones shall be outdoor-rated, Uniform Federal Accessibility Standards (UFAS) and Americans with Disability Act (ADA) compliant, and provide hands-free usage. Phone shall also include cast metal raised letter and Braille signage for UFAS/ADA compliance.
2. Emergency Telephones shall be programmable with up to six different telephone numbers of up to 30 digits each including pauses for each of six telephone number lists.
3. The System shall include auto-answer to allow for monitoring and initiating calls with an Emergency Phone.
4. Emergency Telephones shall be capable of rolling over to each of the six pre-programmed number until the call is answered.
5. Emergency Telephones shall have the capability to access the Public Switched Telephone Network (PSTN) and dialing emergency services or 911
6. Emergency Telephones shall be flush mount to the specified Tower Stanchion and shall include two (2) piece housing construction with full front lip to allow tight gasket seal between the speakerphone and enclosure. Screws shall be tamper free.
7. Emergency Telephones shall have Monitoring/Diagnostic capability at control and monitoring stations and shall include the capability to automatically poll each Emergency Call Box, report incoming calls, identify location, and keep permanent records of all events with the use of a Windows based compatible software package.
8. System shall include auto-answer to allow security to monitor and initiate calls with Emergency Telephones.
9. The System shall include the capability to record a message identifying the location of the caller.
10. It shall remotely be able to adjust speakerphone & microphone sensitivity.

C. Emergency Call Box Tower Stanchion:

1. The Stanchion shall have an opening in the front to accommodate flush mounting the Emergency Telephone specified without the need for supplementary mounting hardware or reducing plates.
2. The tower shall be constructed of 0.25” thick steel, have a structural mounting base and an access panel at the base to facilitate maintenance.
3. The tower shall utilize a high-gloss, multi-coat, corrosion-inhibitive coating that shall be applied to withstand prolonged exposure to hard environments.
   a. Tower shall be sandblasted to SSPC-6 standards before a 2-3 mil layer of rust-inhibitive primer is applied.
4. The tower base plate shall be 2.0” above the tower base and be constructed of 0.75” A-36 Structural Steel, have a 4” diameter center hole for wiring access, have four 1” x 2.31” slots for anchor bolt attachment.
5. The tower wiring access opening shall measure 9”H x 6.75” W.(minimum) and be located 15” above the base of the tower, have a flush cover plate constructed of 0.25” thick steel and held in place by two 1/4" countersunk, tamper-resistant spanner screws.
6. The tower shall have the word “EMERGENCY” emblazoned on all four sides in 3.25” high reflective white letters. Custom lettering, sizes and colors are available.

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7. The tower blue light shall be mounted within an enclosed protective polycarbonate housing with a polycarbonate refractor lens assembly with a prismatic pattern to increase visibility at greater distances.

D. Approved Manufacturer

1. Commend USM-931-HCW with CSH03B Stanchion of CSH-02 Wall Mounts or approved equal.

2.10 ELECTRICAL

A. All electrical components shall have a modular plug for easy service and replacement, and will be equipped with a fuse for protection from transient voltage conditions.

B. Requires 2.5 ampere at 24V AC.

C. Voltage options shall include: 12-24V AC/DC; 120, 240 and 277V AC.

D. The unit shall have the option for Power over Ethernet for connectivity to a VoIP network switch with 802.3af or 802.3at (minimum) capabilities. Requires the LS1000 or IP5000 phone for connectivity to ToolVox or SIP/IAX2 compatible VoIP system.

2.11 COMPLIANCE

A. Americans with Disabilities Act (ADA) compliant

B. UL 60950-1 and UL 2017 listed

C. NFPA 72 Chapter 24 (2010) compliant

D. Meets NEMA 3S requirements

PART 3 - EXECUTION

3.1 GENERAL

A. Provide necessary work as detailed in Section 28 05 00.

3.2 SITE INSPECTIONS

A. Continuously verify that the site conditions are in agreement with the Documents and the design package. Submit a report to the Architect documenting changes to the site or conditions that affect the performance of the System to be installed. For those changes or conditions, which affect System installation or performance, provide (with the report) specification sheets, or written functional requirements to support the findings, and a cost estimate to correct the deficiency. No deficiency shall be corrected without written permission from the Architect.

B. Specific mounting locations, exact wire and cable runs, and conduit routing have not been specified or delineated on the Documents. Coordinate all aspects of the Work with the Architect.

3.3 COORDINATION

A. Coordinate with the Architect, Construction Manager/General Contractor and Division 26 Contractor to ensure that adequate power has been provided and properly located for the security System equipment.

B. Coordinate all network IP addressing and routing with the IT department prior to start of work.

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C. Coordinate all communication requirements with VoIP telephone system provider.

D. Coordinate locations of all devices with the Architect prior to installation.

E. Coordinate finishes and colors of all equipment with the Architect. Submit all finish and graphics for all equipment in public areas to the Architect for approval prior to installation.

3.4 CABLING

A. Install cables and wiring according to requirements in Division 28 Section "Conductors and Cables for Electronic Safety and Security."

B. Contractor shall install wiring in raceway and cable tray except within panels, cabinets, desks, and counters or in accessible ceiling spaces where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables in all areas where they are visible to the public.

C. Install cables without damaging conductors, shield, or jacket.

D. Boxes and enclosures containing security system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered to be accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.

3.5 PREPARATION

A. The Contractor shall create or obtain detailed Project planning forms from manufacturer of the intercom communication system and develop customized forms to suit the Project. Fill in all data available from Project plans and specifications and publish as Project planning documents for review and approval.
1. Record setup data for door stations and master stations.
2. Set up calling groups, linking, and list intercom locations and master stations each device.
3. Assign intercom station names and Caller-ID descriptor. Coordinate with IT Department.
4. Set up event alarms. Establish call-ups between access control events and cameras
5. Prepare and install alarm graphic maps.
6. Develop user-defined fields.
7. Develop screen layout formats.
8. Complete system diagnostics and operation verification.
9. Prepare a specific plan for system testing, startup, and demonstration.
10. Develop acceptance test concept and, on approval, develop specifics of the test.
11. Develop cable and asset management system details; input data from construction documents. Include system schematics and Technical Drawings.

B. In meetings with Architect and Owner, present Project planning documents and review, adjust, and prepare final setup documents. Use final documents to set up system software.

3.6 SYSTEM PROGRAMMING AND DATA ENTRY

A. Any required license keys shall be supplied after operating system is registered with the Manufacturer following completion of the system configuration.

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B. Provide all initial System programming and setup of the SCS including, but not limited to the following:
   1. Initial setup for the interface with the SMS and VMS. The interface shall provide for automatic camera selection upon alarms within the SCS as defined in the Specification.
   2. Graphical Maps and Icons: Coordinate with the Architect to obtain AutoCAD · architectural backgrounds for implementation as graphical maps. Import all AutoCAD background information provided by the Architect and produce a complete set of graphical maps depicting all SCS points.
   3. On-screen alphanumeric identification of each intercom device. Coordinate descriptors with the End-user prior to programming.
   4. Automatic selection of a camera adjacent to an Intercom device upon an invalid device use. Coordinate automatic camera selection requirements with the End-user prior to System programming.
   5. Call routing from each device to designated master station, as indicated on drawings. The call routing is basis of design. Final coordination with Owner is required for accurate and complete call routing programming prior to completion of work.

C. Enter all data needed to make the Security Communication System operational. Deliver the data to the End• user on data entry forms, utilizing data from the Documents, Contractor's field surveys and all other pertinent information in the Contractor's possession required for complete installation of the database. Identify and request from the Architect any additional data needed to make the Security System fully operational and integrated. The completed forms shall be delivered to the End-user for review and approval at least 90 days prior to the Contractor's scheduled date.

3.7 SYSTEM START-UP

A. The Contractor shall not apply power to the SCS until the following items have been completed:
   1. Intercom equipment items have been set up in accordance with manufacturer's instructions.
   2. A visual inspection of the SCS has been conducted to ensure that defective equipment items have not been installed and that there are no loose connections.
   3. System wiring has been tested and verified as correctly connected as indicated.

B. Satisfaction of the above requirements shall not relieve the Contractor of responsibility for incorrect installation, defective equipment items, or collateral damage as a result of Contractor work efforts.

3.8 DEMONSTRATION AND TRAINING

A. All testing and training shall be compliant with Division 01 General Requirements.

B. The contractor shall complete the attached Security Systems Readiness Checklist prior to final Acceptance testing by the Architect. Any construction and installation deficiency or deviations that would impede the contractors from properly signing off on the System Readiness Checklist, shall be identified, itemized and formally reported to the Architect and Construction Manager for review and/or corrective action.

C. All Corrective Field reports must be reviewed and addressed by the Architect, Construction Manager and owner prior to the (5) day burn-in period and Final System Acceptance.

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D. Training shall include a minimum of 4 hours of SCS operator training, and 4 hours of SCS administrative training, either on or off site on a complete and fully operational System parallel and equal to the System being provided, to representatives of the Owner.
   1. Operator training shall include, but not be limited to the following:
      1) Overall System Operation and Features
      2) Manual and automatic intercom camera call-up integration procedures
      3) Remote activation of doors and schedules
   2. Administrative training shall include, but not be limited to the following:
      1) Enhanced operator training
      2) System operation and configuration variables
      3) User login credentials and permissions
      4) Manual and automatic camera call-up integration procedures
      5) Intercom system integration requirements and variables
      6) VoIP SIP Call routing

3.9 SUPPLEMENTAL CONTRACTOR QUALITY CONTROL:

A. The Contractor shall provide the services of technical representatives who are familiar with all components and installation procedures of the selected intercom communications equipment.

B. The Contractor shall be available on the job site during the preparatory and initial phases of quality control, implementation and commissioning to provide technical assistance.

C. The Contractor shall also be available on an as needed basis to provide assistance with follow-up Post Occupancy phases of quality control.

3.10 FIELD QUALITY CONTROL

A. The Contractor shall participate in the testing and validation of the system and shall provide certification that the system installed is fully operational as all construction document requirements have been fulfilled.

B. The Contractor shall provide a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections.

C. Perform the following field tests and inspections and prepare test reports:
   1. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use Class 2, bidirectional, Category 6/6A tester. Test for faulty connectors, splices, and terminations. Test according to ANSI/TIA-568-1, "Commercial Building Telecommunications Cabling Standards - Part 1 General Requirements." Link performance for UTP cables must comply with minimum criteria in ANSI/TIA-568-B.
   2. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.
   3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for

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end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.

3.11 RECORD DRAWINGS

A. Upon completion of the installation of the SCS system, Contractor shall submit written reports including but not limited to the following information:
   1. Complete list of all equipment installed including serial numbers of all components.
   2. Certification that all equipment is properly installed, programmed functional, 100% operational and conforms to Specification, Drawings and Owner's requirements.
   3. Test reports of all zones, devices and equipment.

END OF SECTION 27 20 00

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SECTION 28 23 00

VIDEO SURVEILLANCE SYSTEM

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions", and "Division 1 - General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

B. Related Sections:

1. Division 07 – Through-penetration Firestop Systems
2. Division 26 – Common Work Results for Electrical
3. Division 26 – Low Voltage Electrical Power Conductors and Cables
4. Division 26 – Grounding and Bonding for Electrical Systems
5. Division 26 – Hangers and Supports for Electrical Systems
6. Division 26 – Raceways and Boxes for Electrical Systems
7. Division 26 – Identification for Electrical Systems
8. Division 27 – General Requirements for Telecommunications
9. Division 27 – Common Work Elements for Communications Systems
10. Division 27 – Network Communications Systems
11. Division 27 – Two-Way Communications System
12. Division 27 – Audiovisual Systems
13. Division 27 – Nurse Call/Code Blue
14. Division 28 – Common Work Elements for Electronic Safety and Security
15. Division 28 – Physical Electronic Safety and Security
16. Division 28 – Video Surveillance System

C. Reference Symbols:

1. All device symbols are defined by the appropriate symbol schedules. Because of the scale of the drawings, symbols are shown on drawings as close as possible to the mounting location.

a. Contractor shall coordinate exact locations with all architectural drawings, site plans, reflected ceiling plans, furniture plans, mechanical and electrical drawings as well as all affected trades prior to submittal of any shop drawings.

D. Abbreviations:

1. Refer to Specification Section 28 05 00 for additional information.

E. Definitions:

1. Refer to Specification Section 28 05 00 for additional information.

1.2 SUMMARY

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A. The intent of this specification is to establish a standard of quality, overall system configuration and equipment requirements for the installation of a new TCP/IP-based Video Surveillance System (CCTV). The contractor shall be responsible for providing all design, installation, programming, commissioning, testing and certifications as necessary to provide a complete, fully integrated and operating TCP/IP-based Video Surveillance System in accordance with the Contract Drawings and/or as herein specified.

B. The installation, performance, features, functions, software and programming criteria as specified herein as well as all related specification sections have been designed to offer the maximum system efficiency ease of operation, occupant safety and the protection of equipment as recommended.

1. The scope of work for this project shall include but not limited to providing all necessary conduits, cabling, equipment, components, devices, network video recorders, materials, active network electronics, integration of existing surveillance cameras and ancillary systems in order to provide a seamless and fully integrated video management system.
2. In addition, the video management system platform shall also be fully integrated in a seamless manner with the Stations' new Physical Access Control System (PACS) providing a secondary platform with full operational control and monitoring of all video surveillance system cameras, network recorders and all system functions accessible from the PACS client workstations.
3. The integration to the PACS shall permit system operators to monitor/control and trigger specific surveillance cameras, video monitors and video recordings as well as all related events and alarms annunciated by the physical access control, intrusion detection and emergency call systems.
4. The PACS workstation shall provide a graphical display of all events, controls and functions for all video surveillance system functions and features. Surveillance systems which Do Not conform to the performance criteria or Do Not provide for all functional and operational capabilities in a seamless manner through the PACS platform shall not be acceptable. Refer to all related specification sections for additional information.

1.3 REFERENCES

A. The publications listed below (including amendments, addenda, revisions, supplement, and errata) shall form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

1. Closed Circuit Television Manufacturers Association (CCTMA).
2. Open Network Video Interface Forum (ONVIF)

B. All references to industry and trade association standards as well as all building codes are minimum installation requirements for this system. The codes, standards and agencies listed in specification section 28 05 00 shall form a part of this specification section and all work shall comply with the latest adopted standards.

1. The publications listed in specification section 28 05 00 (including all amendments, addenda, revisions, supplement, and errata) shall form a part of this specification section to the extent referenced. The publications are referenced in the aforementioned

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specification section by the basic designation only.

2. Where the contract drawings and\or specification sections mandate a greater requirement or performance than those specified by the aforementioned referenced codes and standards in section 28 05 00, shall then be the governing requirements for this project. Refer to specification section 28 05 00 for all minimum codes and standards to be applied for this project.

1.4 SUBMITTALS

A. In addition to all requirements as specified by Specification Section 28 05 00 the video surveillance system shall also be provided in accordance with the following requirements:

1. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
2. Shop Drawings: For video surveillance. Include plans, elevations, sections, details, and attachments to other work.
3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
5. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.
6. UPS: Sizing calculations.
7. Wiring Diagrams: For power, signal, and control wiring.

B. Equipment List: Include every piece of equipment by model number, manufacturer, serial number, location, and date of original installation.

1.2 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NECA 1.

C. Comply with NFPA 70.

D. Electronic data exchange between the video surveillance system and access-control system shall comply with SIA TVAC.

1.4 LINE-ITEM PRICING

A. Provide unit price and extended price for each line of material.

B. Include additional line items for the following:

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1. Field installation labor – note if providing union or non-union labor
2. Project management/shop labor
3. Permit fees
4. Taxes
5. First year warrantee and service contract
6. Any subcontractor mark-ups

C. Provide separate pricing to identify any monthly or yearly re-occurring licensing costs required for operation and identify if these costs are included as part of the all-in first year cost in the proposal.

D. Provide separate pricing to identify year 2 and year 3 warrantee and recommended preventative maintenance costs.

E. Provide separate pricing for alternates as indicated in Part 2 below.

1.5 WARRANTY

A. Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.

B. Warranty Period: One year from date of final walk-through and sign-off by the Owner for all parts and labor.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

A. Description:

1. On-premise operating system with sufficient licensing levels and software updates for secure and reliable system operation for a minimum of one year for all devices installed under this scope of work.
2. The Video Surveillance system for this project shall be an extension of the existing VMS, with onsite storage per requirements below.
3. Provide PoE Switches for all IP Based cameras.
4. Camera system units shall be ruggedly built and designed for extreme adverse environments, complying with NEMA Type environmental standards.
5. All system interconnect cables, workstation PCs, PTZ joysticks, and network intermediate devices shall be provided for full performance of specified system.
6. Surge Protection:

a. Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor's entry connection to components.
b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements as recommended by manufacturer for type of line being protected.

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7. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station, control-unit alarm display shall identify tamper alarms and indicate locations.

2.2 NETWORK VIDEO RECORDERS

A. Manufacturer –Extend existing ExacqVision system and add as required to meet capture retention requirements.

1. NVR storage additional capacity shall be calculated based on following parameters:

a. Minimum video retention rate – 60 days
b. Minimum camera frame rate – 15 frames per second for interior cameras and 30 frames per second for exterior cameras
c. Minimum camera resolution – Maximum resolution of each specified camera.
d. Motion-based recording for all cameras with mandatory (5) seconds pre-alarm recording. Continuous recording for all exterior Cameras
e. Spare storage capacity – 20%.

2.3 IP CAMERA SYSTEMS

A. Color Dome Camera: Assembled and tested as a manufactured unit, containing fixed color camera, varifocal lens, and vandal resistant dome assembly.

B. Provide all wall and ceiling mounting hardware and brackets as indicated on drawing details. Coordinate color of mounting hardware with owner and architect before installation.

C. PTZ Camera: Assembled and tested as a manufactured unit, containing color camera, varifocal lens, vandal resistant dome assembly, Pan Tilt, Zoom capability and controls.

D. Approved list of Camera Manufacturers:

1. Axis

2. Hanwha – Approved equal.

2.4 POWER SUPPLIES

A. Low-voltage power supplies matched for voltage and current requirements of cameras and accessories, and of type as recommended by manufacturer of camera.

B. Annunciation: Indicate change in system condition and switching of system or component to backup power.

PART 3 - EXECUTION

3.1 VIDEO SURVEILLANCE SYSTEM INSTALLATION

A. Install cameras so that each is level and plumb.

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B. Install cameras with 84-inch-minimum clear space below cameras and their mountings. Maximum outdoor camera height shall not exceed 13ft above ground. Change type of mounting to achieve required clearance. Keep camera views free from all obstructions.

C. Install power supplies and other auxiliary components at control stations unless otherwise indicated.

D. Install tamper switches on components indicated to receive tamper switches, arranged to detect unauthorized entry into system-component enclosures and mounted in self-protected, inconspicuous positions.

E. Identify system components, wiring, cabling, and terminals according to Section "Identification for Electrical Systems."

F. Miscellaneous hardware required for installation shall be suitable for the purpose for which it is used. Hardware includes nuts, bolts, screws, washers, miscellaneous fasteners, terminals, terminal strips, tie wraps, and related parts. Where the equipment manufacturer specifies hardware for use in the installation, the hardware specified shall be used. The finish on all hardware and fasteners shall be suitable for the environment in which it will be used and shall be selected to minimize corrosion or deterioration due to moisture, sunlight, or temperature extremes.

G. All electrical power work and conduit work shall be by licensed electricians.

H. The Security Systems Contractor will be required to install and test local equipment, programming it with an IP address specified by the Owner. This support shall include the coordination of dates and times for programming and the testing of individual devices following programming. In all circumstances, the Security Systems Contractor's work shall not be considered complete until the equipment has been programmed and tested to the satisfaction of the Owner.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:

    a. Prepare equipment list described in "Informational Submittals" Article.
    b. Verify operation of auto-iris lenses.
    c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.

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d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
e. Set and name all preset positions; consult Owner's personnel.
f. Set sensitivity of motion detection.
g. Connect and verify responses to alarms.
h. Verify operation of control-station equipment.

3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

C. Video surveillance system will be considered defective if it does not pass tests and inspections.

D. Prepare and issue test and inspection reports.

E. After work is completed, and prior to requesting the Final Acceptance Test, the Security Contractor shall conduct a final inspection and pre-test all equipment and system features. The Security Contractor shall correct any deficiencies discovered as the result of the inspection and pre-test.

F. The Security Contractor shall notify Owner and Engineer to request a Final Acceptance Test. The request for Acceptance Test shall constitute a certification from the Security Contractor that:

1. All work is complete and in compliance with the Contract Documents.
2. All systems have been tested.
3. All corrections have been made.

G. Technicians performing the acceptance test shall have been involved in the installation of the system and shall be thoroughly familiar with all aspects of the work.

H. The Security Contractor shall provide all ladders, tools, test equipment as needed to accomplish the Final Acceptance Test.

I. Any portions of the work found to be deficient or not in compliance with the Contract Documents will be rejected.

3.3 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

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3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's Security personnel to adjust, operate, and maintain video-surveillance equipment.

B. Train Owner's maintenance personnel on equipment operation, startup and shutdown, troubleshooting, servicing, and preventative maintenance procedures. Review the data contained in the Operating and Maintenance Manuals with Owner's personnel. Training shall occur separate from startup activities. Provide 8 hours of training minimum.

END OF SECTION 28 23 00

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SECTION 28 46 21.11

ADDRESSABLE FIRE-ALARM SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, and Section 260000 "General Requirements for Electrical," apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Addressable fire-alarm system.
2. Fire-alarm control panel (FACP).
3. Manual fire-alarm boxes.
4. System smoke detectors.
5. Duct smoke detectors.
6. Carbon monoxide detectors.
7. Heat detectors.
8. Fire-alarm notification appliances.
9. Fire-alarm graphic annunciator panel.
10. Fire-alarm remote annunciator panel.
11. Existing Campus Buildings Fire-alarm remote annunciator panels.
    a. Candee Building
    b. Medical Building
    c. Prickett Building
    d. Guest Pavilion 1
    e. Guest Pavilion 2
    f. Dietary Assembly
    g. Utility Building
    h. Laundry/Utility Building
    i. Maintenance Building
12. Fire-alarm addressable interface devices.
13. Digital alarm communicator transmitters (DACTs).

B. Related Requirements:

1. Division 08 “Openings.”
2. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" or Section 260523 "Control Voltage Electrical Power Cables" for cables and conductors for fire-alarm systems.

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1.3 DEFINITIONS

A. CI: Circuit Integrity Cable

B. DACT: Digital Alarm Communicator Transmitter.

C. EAP: Elevator Annunciator Panel

D. EMT: Electrical Metallic Tubing.

E. FAAP: Fire Alarm Annunciator Panel.

F. FACP: Fire Alarm Control Panel.

G. NAC: Notification Appliance Circuit

H. VECP: Voice Evacuation Control Panel.

I. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the 2007 Energy Independence and Security Act (EISA).

J. NICET: National Institute for Certification in Engineering Technologies.

K. PC: Personal computer.

L. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:

1. Control Voltage: Listed and labeled for use in remote-control, signaling, and power-limited circuits supplied by a Class 2 or Class 3 power supply having rated output not greater than 150 V and 5 A, allowing use of alternate wiring methods complying with NFPA 70, Article 725.
2. Low Voltage: Listed and labeled for use in circuits supplied by a Class 1 or other power supply having rated output not greater than 1000 V, requiring use of wiring methods complying with NFPA 70, Article 300, Part I.

M. Class A Wiring: Circuits arranged and electrically supervised so a single break or single ground fault condition will be indicated by a trouble signal at the fire alarm control panel (FACP) and the circuit will continue to be capable of operation for its intended service in the faulted condition no matter where the break or ground fault condition occurs.

1.4 ACTION SUBMITTALS

A. Approved Permit Submittal: Submittals must be approved by authorities having jurisdiction prior to submitting them to Architect.

B. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

C. Shop Drawings: For fire-alarm system.

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1. Comply with recommendations and requirements in "Documentation" section of "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, and details, including details of attachments to other Work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Special Systems drawings as required by Section 260000. In addition to the requirements of Section 260000, the drawings shall indicate the candela ratings for each strobe. Strobes shall provide proper candela levels for each space in strict accordance with ADA requirements.
5. Graphic Annunciator panel details as required by authorities having jurisdiction.
6. Detail assembly and support requirements.
7. Include voltage drop calculations for notification-appliance circuits.
8. Include battery-size calculations.
9. Include input/output matrix.
10. Include written statement from manufacturer that equipment and components have been tested as a system and comply with requirements in this Section and in NFPA 72.
11. Include performance parameters and installation details for each detector.
12. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
13. Provide program report showing that air-sampling detector pipe layout balances pneumatically within airflow range of air-sampling detector.
14. Provide control wiring diagrams for fire-alarm interface to HVAC; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring and equipment required for HVAC unit shutdown on alarm.
    c. Locate detectors in accordance with manufacturer's written instructions.
    d. Show air-sampling detector pipe routing.

15. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
16. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

D. Delegated Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by qualified professional engineer responsible for their preparation.

1. Drawings showing location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of device.
2. Design Calculations: Calculate requirements for selecting spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

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1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

a. Comply with "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire-Alarm and Emergency Communications System Record of Completion Documents" in accordance with "Completion Documents" Article in "Documentation" section of "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between devices and equipment. Each conductor must be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
g. Record copy of site-specific software.
h. Provide "Inspection and Testing Form" in accordance with "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

i. Manufacturer's required maintenance related to system warranty requirements.
j. Abbreviated operating instructions for mounting at FACP and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.

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3. Smoke Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
5. Keys and Tools: One extra set for access to locked or tamper proofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in system. Provide in box or cabinet with compartments marked with fuse types and sizes.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. The system shall be installed under the supervision of the manufacturer's representative who has been trained and certified by the factory. Provide documentation to support this training. The manufacturer's representative must have a satisfactory record of performance, together with sufficient stock of replacement parts, as demonstrated by at least five systems of the same type, similar size and duty.

2. Personnel must be trained and certified by manufacturer for installation of units required for this Project.
3. Installation must be by personnel certified by NICET as fire-alarm Level IV technician.
4. Obtain certification by NRTL in accordance with NFPA 72.
5. Licensed or certified by authorities having jurisdiction.

B. Code Compliance:

1. Provide a Fire Alarm and Signaling System conforming to the requirements of the latest edition of the following publications:

a. International Code Council, Inc. (ICC) Codes :

1) International Building Code (IBC) – 2015 edition
2) International Fire Code (IFC)
3) International Mechanical Code (IMC)

b. National Fire Protection Association (NFPA):

1) NFPA 13, “Sprinkler Systems”
2) NFPA 20, “Centrifugal Fire Pumps”
3) NFPA 70, “National Electrical Code” – 2017 edition
4) NFPA 72, “National Fire Alarm and Signaling Code”
5) NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems”
6) NFPA 101, “Life Safety Code”
7) NFPA 720, Standard for the Installation of Carbon Monoxide (CO) Detection and Warning Equipment, 2012 Edition
8) NFPA 1221, “Emergency Services Communications Systems”

c. American National Standards:

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1) ANSI Standards: ANSI/ASME A17.1, "Safety Code for Elevators and Escalators"
2) ANSI/NECA Standard 305-2001, "Standard for Fire Alarm System Job Practices"

d. Underwriters Laboratories:

1) UL-864 Control Units for Fire Protective Signaling Systems (9th Edition)
2) UL-2572 Control Units for Mass Notification System
3) UL-268 Smoke Detector for Fire Protective Signaling Systems
4) UL-217 Smoke Detectors for Single and Multiple Station
5) UL-521 Heat Detectors for Fire Protective Signaling Systems
6) UL-464 Audible Signaling Appliances
7) UL-1971 Visual Signaling Appliances
8) UL-38 Manually Actuated Signaling Boxes
9) UL-1481 Power Supplies for Fire Protective Signaling Systems
10) Fire Protection Equipment Directory - latest edition.

e. National Electrical Manufacturers Association (NEMA)
f. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)

2. Factory Mutual (FM) Compliance: Provide fire alarm systems and components that are Factory Mutual approved.

3. Compliance with Local Requirements: Comply with the applicable building code, local ordinances, and regulations, and the requirements of the Authority Having Jurisdiction (AHJ).

4. Single-Source Responsibility: Obtain fire alarm components from a single source who assumes responsibility for compatibility for system components.

1.8 COORDINATION WITH OTHER TRADES

A. Coordinate the installation of Fire Alarm equipment, and the interface of the Fire Alarm system with work specified under the following Specification Sections:

1. Division 08 Section, Openings
2. Division 14 Section, Conveying Equipment
3. Division 21 Section, Fire Suppression
4. Section 230923 – Direct Digital Control (DDC) System for HVAC
5. Section 230993.11 - Sequence of Operations for HVAC DDC
6. Section 275223 - Nurse Call-Code Blue Systems

1.9 UL CERTIFICATION

A. Provide the services and equipment of a fire alarm service company listed by Underwriters Laboratories, Inc., in its directory as being capable of furnishing the signaling systems specified herein. The fire alarm service company shall be authorized to, and shall issue a certificate for

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the equipment described herein as its representation that such equipment all connected wiring and devices which form the specified system together with installation and maintenance service are in compliance with requirements established by Underwriters Laboratories, Inc. A UL certificate shall be issued to the Owner with a copy in the Operations and Maintenance Manual.

1.10 INSPECTIONS AND SERVICE CONTRACT

A. Include in the contract, the services of the fire alarm supplier to provide maintenance of the system during the warranty period. Maintenance shall include a minimum of four (4) site inspections (quarterly) to review the system and components. Review shall include checking system battery backup, initiating device sensitivity, lamp test and all other maintenance procedures as required or recommended by NFPA-72 or by the fire alarm system manufacturer. Written reports shall be submitted to the Owner stating the results of the tests, corrective measures taken for any defects found and list of items or components replaced.

B. At the end of the warranty period, offer the Owner a service contract covering the complete system for an additional twelve (12) months.

1.11 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail because of defects in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ADDRESSABLE FIRE-ALARM SYSTEM

A. Description:

1. Noncoded, UL-certified addressable system, with multiplexed signal transmission and voice-and-strobe notification for evacuation.

B. Performance Criteria:

1. Regulatory Requirements:

a. Fire-Alarm Components, Devices, and Accessories: Listed and labeled by a NRTL in accordance with NFPA 70 for use with selected fire-alarm system and marked for intended location and application.

2. General Characteristics:

a. Automatic sensitivity control of certain smoke detectors.
b. Fire-alarm signal initiation must be by one or more of the following devices and systems:

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1) Manual stations.
2) Heat detectors.
3) Smoke detectors.
4) Duct smoke detectors.
5) Carbon monoxide detectors.
6) Automatic sprinkler system water flow.
7) Fire standpipe system.
8) Fire pump running.

c. Refer to Fire Alarm System Function Matrix on drawings for Alarm and Supervisory functions.

d. Supervisory signal initiation must be by one or more of the following devices and actions:

1) Valve supervisory switch.
2) Alert and Action signals of air-sampling detector system.
3) Elevator shunt-trip supervision.
4) Fire pump is running.
5) Fire pump has lost power.
6) Power to fire pump has phase reversal.
7) Zones or individual devices have been disabled.
8) FACP has lost communication with network.

e. System trouble signal initiation must be by one or more of the following devices and actions:

1) Open circuits, shorts, and grounds in designated circuits.
2) Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3) Loss of communication with addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4) Loss of primary power at FACP.
5) Ground or single break in internal circuits of FACP.
6) Abnormal ac voltage at FACP.
7) Break in standby battery circuitry.
8) Failure of battery charging.
9) Abnormal position of switch at FACP or annunciator.
10) Voice signal amplifier failure.
11) Hose cabinet door open.

f. Network Communications:

1) Provide network communications for fire-alarm system in accordance with fire-alarm manufacturer's written instructions.
2) Provide network communications pathway per manufacturer's written instructions and requirements in NFPA 72 and NFPA 70.
3) Provide integration gateway using BACnet for connection to building automation system.

g. System Printer:

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1) Printer must be listed and labeled as integral part of fire-alarm system.

h. Document Storage Box:

1) Description: Enclosure to accommodate standard 8-1/2-by-11 inch manuals and loose document records. Legend sheet will be permanently attached to door for system required documentation, key contacts, and system information. Provide two key ring holders with location to mount standard business cards for key contact personnel.
2) Material and Finish: 18-gauge cold-rolled steel; four mounting holes.
3) Color: Red powder-coat epoxy finish.
4) Labeling: Permanently screened with 1 inch high lettering "SYSTEM RECORD DOCUMENTS" with white indelible ink.
5) Security: Locked with 3/4 inch barrel lock. Provide solid 12 inch stainless steel piano hinge.

i. Elevator Interfaces:

1) Provide interface to the building elevator(s) in strict accordance with all requirements and recommendations of ANSI Standard ANSI/ASME A17.1, "Safety Code for Elevators and Escalators," latest edition, NFPA-72, "The National Fire Alarm Code" and requirements of the local Elevator Inspector.

2) Provide interface connections between fire alarm system and elevator for:

1) Elevator recall – primary and alternate floor.
2) Illuminate recall indicator in each elevator cab.
3) Power shut down via shunt trip circuit breakers for elevator power, controls, cab lighting, etc.

3) Provide all interface modules, relays, wiring, connections, etc.

4) Derive 120 volt control power for interfaces from elevator control disconnect in elevator machine room. All control wiring for elevator shunt trip functions shall be supervised by the fire alarm system in accordance with NFPA-72, section 6.16.4.4. and other applicable requirements. Provide delay between activation of heat detector and initiation of shunt trip equal to time that it takes the elevator cab to travel from the top of the hoistway to the lowest recall level, per NFPA-72 Annex A, paragraph A6.16.4.4.

2.2 FIRE-ALARM CONTROL PANEL (FACP)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Silent Knight; Honeywell International, Inc. (Basis of Design)
2. Gamewell-FCI; Honeywell International, Inc.
3. Notifier; Honeywell International, Inc.
4. Edwards; Carrier Global Corporation.

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B. Description: Field-programmable, microprocessor-based, modular, power-limited design with electronic modules.

C. Performance Criteria:

1. Regulatory Requirements: Comply with NFPA 72 and UL 864.
2. General Characteristics:

a. System software and programs must be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining information through failure of primary and secondary power supplies.
b. Include real-time clock for time annotation of events on event recorder and printer.
c. Provide communication between FACP and remote circuit interface panels, annunciators, and displays.
d. FACP must be listed for connection to central-station signaling system service.
e. Provide nonvolatile memory for system database, logic, and operating system and event history. System must require no manual input to initialize in the event of complete power down condition. FACP must provide minimum 500-event history log.
f. Addressable Initiation Device Circuits: FACP must indicate which communication zones have been silenced and must provide selective silencing of alarm notification appliance by building communication zone.

1) Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: FACP must be listed for releasing service.

g. Fire-Alarm Annunciator: Arranged for interface between human operator at FACP and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.

1) Annunciator and Display: LCD, 80 characters, minimum.
2) Keypad: Arranged to permit entry and execution of programming, display, and control commands.

h. Alphanumeric Display and System Controls: Arranged for interface between human operator at FACP and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.

1) Annunciator and Display: LCD, three line(s) of 80 characters, minimum.
2) Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into system for control of smoke-detector sensitivity and other parameters.

i. System circuits shall be configured as follows: Addressable analog loops shall be wired as Class A. Each addressable analog loop shall be circuited so that device loading does not exceed 80% of loop capacity in order to leave for space for future devices. Notification Appliance Circuits shall be wired for Class A operation. Where it is necessary to interface conventional initiating devices provide intelligent input modules to supervise Class B zone wiring.

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j. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1) Pathway Class Designations: NFPA 72, Class A.
2) Pathway Survivability: Level 0.
3) Install no more than 256 addressable devices on each signaling-line circuit.
4) Install fault circuit isolators to comply with circuit performance requirements of NFPA 72 or with manufacturer's written instructions, whichever is more conservative.

k. Serial Interfaces:

1) One dedicated RS 485 port for central-station operation using point ID DACT.
2) One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
3) One USB and RS 232 port for PC configuration.
4) One RS 232 port for voice evacuation interface.
5) Provide interface to tie into existing campus Simplex fire alarm system for monitoring of building fire alarm system.

l. Smoke-Alarm Verification:

1) Initiate audible and visible indication of "alarm-verification" signal at FACP.
2) Activate approved "alarm-verification" sequence at FACP and detector.
3) Record events by system printer.
4) Sound general alarm if alarm is verified.
5) Cancel FACP indication and system reset if alarm is not verified.

m. Notification-Appliance Circuit:

1) Audible appliances must sound in three-pulse temporal pattern, as defined in NFPA 72.
2) Where notification appliances provide signals to sleeping areas, alarm signal must be 520 Hz square wave with intensity 15 dB above average ambient sound level or 5 dB above maximum sound level, or at least 75 dB(A-weighted), whichever is greater, measured at pillow.
3) Visual alarm appliances must flash in synchronization where multiple appliances are in same field of view, as defined in NFPA 72.

n. Elevator Recall: Initiate by one of the following alarm-initiating devices:

1) Elevator lobby detectors except lobby detector on designated floor.
2) Smoke detectors in elevator control room.
3) Smoke detectors in elevator hoistway.

o. Elevator controller must be programmed to move cars to alternate recall floor if lobby detectors located on designated recall floors are activated.
p. Water-flow alarm connected to sprinkler in elevator shaft and elevator machine room must shut down elevators associated with location without time delay.

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1) Water-flow switch associated with sprinkler in elevator pit may have delay to allow elevators to move to designated floor.

q. Remote Smoke-Detector Sensitivity Adjustment: Controls must select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory and print out final adjusted values on system printer.

r. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided in separate cabinet located in fire command center.

s. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of central-control microphone. Amplifiers must comply with UL 1711.

1) Allow application of, and evacuation signal to, indicated number of zones and simultaneously allow voice paging to other zones selectively or in combination.
2) Programmable tone and message sequence selection.
3) Standard digitally recorded messages for "Evacuation" and "All Clear."
4) Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of FACP.

t. Status Annunciator: Indicate status of various voice/alarm speaker zones and status of firefighters' two-way telephone communication zones.

u. Preamplifiers, amplifiers, and tone generators must automatically transfer to backup units, on primary equipment failure.

v. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from other printed indications. Also, print system reset event, including same information for device, location, date, and time. Commands initiate printing of list of existing alarm, supervisory, and trouble conditions in system and historical log of events.

w. Primary Power: 24 V(dc) obtained from 120 V(ac) service and power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals, and supervisory and DACT must be powered by 24 V(dc) source.

x. Alarm current draw of entire fire-alarm system must not exceed 80 percent of power-supply module rating.

y. Secondary Power: 24 V(dc) supply system with batteries, automatic battery charger, and automatic transfer switch.

z. Batteries: Sealed, valve-regulated, lead calcium type.

D. Accessories:

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1. Instructions: Computer printout or typewritten instruction card mounted behind plastic or glass cover in stainless steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe functional operation of system under normal, alarm, and trouble conditions.

E. Fire Alarm Control Panel shall be enclosed in a surface mounted cabinet, or multiple cabinets as required to house all control panel components. Provide a separate enclosure directly adjacent to Fire Alarm Control Panel to house a complete set of system as-built drawings and documentation. All fire alarm system cabinets shall be keyed alike.

2.3 AUDIO PAGING AND EMERGENCY EVACUATION SUBSYSTEM:

A. Provide an Audio Paging and Emergency Evacuation subsystem to provide spoken voice type evacuation signals throughout the building.

B. The Audio Paging and Emergency Evacuation subsystem which shall provide fully digitized and multiplexed audio voice evacuation signals. Up to 32 minutes of pre-recorded audio shall be transmittable over one of 8 audio channels over a single pair of wires. The system shall not require mechanical potentiometers to make adjustment of audio levels within the system, as these devices are prone to require re-adjustment over time, and may fail under uncontrolled field conditions.

C. One amplifier shall be supplied per speaker circuit to enhance system survivability. The system shall be arranged to provide signals for total evacuation of the building. Provide a minimum of two separate speakers circuits throughout the building. Speakers shall be alternately circuited across the two circuits, so that no area is left without a signal upon failure of one circuit or amplifier.

D. Integrated Audio System:

1. The Fire Alarm System shall incorporate a true digital integrated audio system into the network, multiplexing 8 independent audio channels over a single pair of wires. The system shall include distributed audio amplifiers, one for each speaker circuit, for system survivability.
2. The system shall provide a local temporal back up tone at each amplifier to allow evacuation signals to be broadcast in the protected premises in the event of a loss of data communication from the Fire Alarm Control Panel or Voice Evacuation Control Panel.
3. A digital message unit shall be provided which provides up to 32 minutes of pre-recorded emergency messaging. The message contained in the fully digital message unit shall be recordable in the field on a computer.

E. Voice Evacuation Control Panel (Audio Source Unit 3-ASU):

1. The Fire Detection and Alarm System shall be provided with a fully integrated Audio Paging and Emergency Evacuation subsystem. The Voice Evacuation Control Panel shall include a paging microphone, digital message playback unit, and 8 fully digitized and multiplexed audio channels. Four dedicated page mode control switches shall provide the emergency operator with instantaneous one touch paging to safely control the staged evacuation of building occupants. Automatic programming shall dynamically group the most frequently targeted paging zones.

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2. The "All Call" switch will direct the manual page to all areas served by the Audio Paging and Emergency Evacuation subsystem.
3. The Page to Evac switch will direct the manual page to those building areas automatically receiving the Evacuation Signal.
4. The Page to Alert switch will direct the manual page to those building areas automatically receiving the Alert Signal.
5. The All-Call Minus switch will direct the manual page to those building areas which are programmed to receive the auxiliary and general channel connections such as stairwells and elevator cabs.
6. The system shall have paging control switches and LEDs to support specific zone selection. The zone control / displays shall confirm amplifier selection and annunciate amplifier and amplifier circuit trouble.
7. The system shall automatically deliver a pre-announce tone of 1000 Hz for three seconds when the emergency operator presses the microphone talk key. A "ready to page" LED shall flash during the pre-announce and turn steady when the system is ready for the user's page delivery.
8. The system shall include a page deactivation timer which activates for 3 seconds when the emergency user release the microphone talk key. Should the user subsequently press the microphone key during the deactivation period a page can be delivered immediately. Should the timer complete its cycle the system shall automatically restore emergency signaling and any subsequent paging will be preceded by the pre-announce tone. A VU display shall display voice level to the emergency operator.
9. Mount the Voice Evacuation Control Panel in a flush mounted cabinet adjacent to the Fire Alarm Annunciator where indicated on the drawings. Provide power from the circuits serving the Fire Alarm Control Panel.

F. Audio Amplifiers:

1. Each audio power amplifier shall have integral audio signal de-multiplexers, allowing the amplifier to select any one of eight digitized audio channels. The channel selection shall be directed by the system software. Up to 8 multiple and different audio signals must be able to be broadcast simultaneously from the same system network node.
2. Each amplifier output shall include a dedicated, supervised 25/70 Vrms speaker circuit which is suitable for connection of emergency speaker appliances. Each amplifier shall also include a notification appliance circuit rated at 24Vdc @ 3.5A for connection of visible (strobe) appliances. This circuit shall be fully programmable and it shall be possible to define the circuit for the support of audible, visible, or ancillary devices.
3. Standby Audio amplifiers shall be provided that automatically sense the failure of a primary amplifier, and automatically program themselves to select and de-multiplex the same audio information channel of the failed primary amplifier, and fully replace the function of the failed amplifier.
4. In the event of a total loss of audio data communications, all amplifiers will default to the local "EVAC" tone generator channel. If the Fire Alarm Control Panel has an alarm condition, then all amplifiers will sound the EVAC signal on their connected speaker circuits.
5. In the event of a loss of the fully digitized, multiplexed audio connection, the audio amplifiers shall automatically default to an internally generated alarm tone which shall be operated at a 3-3-3 temporal pattern.
6. The audio amplifiers shall automatically detect a short circuit condition on the connected speaker circuit wiring, and shall inhibit themselves from driving into that short circuit condition.

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G. Voice Evacuation System Notification Appliances:

1. Notification appliances for voice evacuation shall be speakers, as specified below in section "Fire Alarm Notification Appliances."

2.4 MANUAL FIRE-ALARM BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Silent Knight; Honeywell International, Inc. (Basis of Design)
2. Gamewell-FCI; Honeywell International, Inc.
3. Notifier; Honeywell International, Inc.
4. Edwards; Carrier Global Corporation.

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes must be finished in red with molded, raised-letter operating instructions in contrasting color; must show visible indication of operation; and must be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to FACP.
2. Station Reset: Key.
3. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm.
4. Able to perform at up to 90 percent relative humidity at 90 deg F.
5. Material: Manual stations made of Lexan polycarbonate.
6. Able to be used in indoor areas.
7. Each pull station shall be identified with the following sign: "IN CASE OF FIRE SOUND ALARM AND CALL FIRE DEPARTMENT".

2.5 SYSTEM SMOKE DETECTORS

A. Photoelectric Smoke Detectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Silent Knight; Honeywell International, Inc. (Basis of Design)
b. Edwards; Carrier Global Corporation.
c. Gamewell-FCI; Honeywell International, Inc.
d. Notifier; Honeywell International, Inc.

2. Performance Criteria:

a. Regulatory Requirements:

1) NFPA 72.

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2) UL 268.

b. General Characteristics:

1) Detectors must be four-wire type.
2) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACP.
3) Base Mounting: Detector and associated electronic components must be mounted in twist-lock module that connects to fixed base. Provide terminals in fixed base for connection to building wiring.
4) Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
5) Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
6) Detector address must be accessible from FACP and must be able to identify detector's location within system and its sensitivity setting.
7) Operator at FACP, having designated access level, must be able to manually access the following for each detector:

a) Primary status.
b) Device type.
c) Present average value.
d) Present sensitivity selected.
e) Sensor range (normal, dirty, etc.).

8) Detector must have functional humidity range within 10 to 90 percent relative humidity.
9) Color: White.
10) Remote Control: Unless otherwise indicated, detectors must be digital-addressable type, individually monitored at FACP for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by FACP.
11) Multiple levels of detection sensitivity for each sensor.
12) Sensitivity levels based on time of day.

2.6 DUCT SMOKE DETECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Silent Knight; Honeywell International, Inc. (Basis of Design)
2. Gamewell-FCI; Honeywell International, Inc.
3. Notifier; Honeywell International, Inc.
4. Edwards; Carrier Global Corporation.

B. Description: Photoelectric-type, duct-mounted smoke detector.

C. Performance Criteria:

1. Regulatory Requirements:

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a. NFPA 72.
b. UL 268A.

2. General Characteristics:

a. Detectors must be four-wire type.
b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACP.
c. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
d. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
e. Detector address must be accessible from FACP and must be able to identify detector's location within system and its sensitivity setting.
f. Operator at FACP, having designated access level, must be able to manually access the following for each detector:

1) Primary status.
2) Device type.
3) Present average value.
4) Present sensitivity selected.
5) Sensor range (normal, dirty, etc.).

g. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with supplied detector for smoke detection in HVAC system ducts.
h. Each sensor must have multiple levels of detection sensitivity.
i. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
j. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.7 CARBON MONOXIDE DETECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Silent Knight; Honeywell International, Inc. (Basis of Design)
2. Gamewell-FCI; Honeywell International, Inc.
3. Notifier; Honeywell International, Inc.
4. Edwards; Carrier Global Corporation.

B. Description: Carbon monoxide detector listed for connection to fire-alarm system.

C. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72
b. NFPA 720.
c. UL 2075.

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2. General Characteristics:

a. Mounting: Adapter plate for outlet box mounting.
b. Testable by introducing test carbon monoxide into sensing cell.
c. Detector must provide alarm contacts and trouble contacts.
d. Detector must send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
e. Locate, mount, and wire in accordance with manufacturer's written instructions.
f. Provide means for addressable connection to fire-alarm system.
g. Test button simulates alarm condition.

2.8 HEAT DETECTORS

A. Fixed-Temperature-Type Heat Detectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Silent Knight; Honeywell International, Inc. (Basis of Design)
b. Edwards; Carrier Global Corporation.
c. Gamewell-FCI; Honeywell International, Inc.
d. Notifier; Honeywell International, Inc.

2. Performance Criteria:

a. Regulatory Requirements:

1) NFPA 72.
2) UL 521.

b. General Characteristics:

1) Actuated by temperature that exceeds fixed temperature of 135 deg F.
2) Mounting: Twist-lock base interchangeable with smoke-detector bases.
3) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACP.
4) Detector must have functional humidity range of 10 to 90 percent.
5) Color: White.

2.9 FIRE-ALARM NOTIFICATION APPLIANCES

A. Fire-Alarm Voice/Tone Notification Appliances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Silent Knight; Honeywell International, Inc. (Basis of Design)
b. Edwards; Carrier Global Corporation.
c. Gamewell-FCI; Honeywell International, Inc.

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d. Notifier; Honeywell International, Inc.

2. Description: Notification appliances capable of outputting voice evacuation messages.
3. Performance Criteria:

a. Regulatory Requirements:

1) NFPA 72.
2) UL 1480.

b. General Characteristics:

1) Speakers for Voice Notification: Locate speakers for voice notification to provide intelligibility requirements of "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
2) High-Range Units: Rated 2 to 15 W.
3) Low-Range Units: Rated 1 to 2 W.
4) Mounting: Flush.
5) Matching Transformers: Tap range matched to acoustical environment of speaker location.
6) Combination Devices: Factory-integrated audible and visible devices in single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
7) Fire alarm systems must have permanently installed audible and visible alarms in hearing/visually impaired residential units complying with NFPA 72, except that the maximum allowable sound level of audible notification appliances complying with section 4-3.2.1 of NFPA 72 must have a sound level no more than 110 dB at the minimum hearing distance from the audible appliance.

B. Fire-Alarm Visible Notification Appliances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Silent Knight; Honeywell International, Inc. (Basis of Design)
b. Edwards; Carrier Global Corporation.
c. Gamewell-FCI; Honeywell International, Inc.
d. Notifier; Honeywell International, Inc.

2. Performance Criteria:

a. Regulatory Requirements:

1) NFPA 72.
2) UL 1971.

b. General Characteristics:

1) Rated Light Output:

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a) 15/30/75/110 cd, selectable in field.

2) Clear or nominal white polycarbonate lens mounted on aluminum faceplate.
3) Mounting: Wall mounted unless otherwise indicated.
4) For units with guards to prevent physical damage, light output ratings must be determined with guards in place.
5) Flashing must be in temporal pattern, synchronized with other units.
6) Strobe Leads: Factory connected to screw terminals.
7) Mounting Faceplate: Factory finished, white.

2.10 DOOR HOLDING APPLIANCES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Silent Knight; Honeywell International, Inc. (Basis of Design)
2. Gamewell-FCI; Honeywell International, Inc.
3. Notifier; Honeywell International, Inc.
4. Edwards; Carrier Global Corporation.

B. Door Holders shall have a holding force of 25 pounds. The housing shall be finished in zinc. Wall mounted units shall mount to single gang flush mounted boxes. Floor mounted units shall be utilized where shown on the drawings, or where wall mounted units are not applicable as specifically approved by the Architect. The Magnetic Door Holders shall operate at 24 VDC and shall receive all required power from the Fire Alarm Control Panel. Provide EST 1500 series door holders in configuration to suit the specific requirements of each installation.

C. Door Closer/Holder Hardware Sets shall be provided where indicated on the drawings, or where a magnetic door holder is not suitable due to door installation requirements. Door closer holder hardware sets shall consist of a hydraulic door closer mechanism with electric solenoid holding mechanism, which shall automatically release and close the indicated door. The door closer/holder devices shall have cast iron cylinders and two separately adjustable, non-critical closing speed valves plus adjustable back-check as standard equipment. The arm shall be connected to the track with a low friction roller assembly. Units shall operate at 24 VDC and shall be suitable for concealed wiring. Door closer/holders shall provide for holding doors in an open position at any of the following positions: 85, 90, 95, 100 degrees. The position shall be selectable by track location. The door closer/holder shall hold the door in an open position during normal operation and shall automatically release the door upon loss of signal from the Fire Alarm Control Panel (FACP). Door closer/holder hardware sets shall be as manufactured by Von Duprin or approved equal, and shall be certified compatible with the Fire Alarm System. Exact configuration shall be suitable for the door installation on which the equipment is to be installed.

2.11 SPRINKLER FLOW SWITCHES

A. Sprinkler flow switches shall be furnished under Division 25.

B. Provide the necessary intelligent monitoring modules for addressing the devices. Make all final connections between the switch and the intelligent monitoring module.

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2.12 SPRINKLER VALVE POSITION (TAMPER) SWITCHES

A. Sprinkler valve position (tamper) switches shall be furnished under Division 25.

B. Provide the necessary intelligent monitoring modules for addressing the devices. Make all final connections between the switch and the intelligent monitoring module.

2.13 SYSTEM EVENT AND STATUS PRINTER

A. The event and status printer shall be a 9 pin, impact, dot-matrix printer with a minimum print speed of 200 characters per second at 10 characters per inch. Printer parameters shall be set up with a menu drive program in the printer. The serial cable connecting the Fire Alarm Control Panel to the Printer shall be supervised. The serial printer shall support short haul modems or Fiber-Optics modules. The printers shall list the time, date, type, and user defined message for each event printed. It shall be possible to support multiple printers per CPU. It shall be possible to define which event types are sent to the printer(s) including alarm, supervisory, trouble, monitor, and service groups.

B. The printer shall be powered from 115 VAC and shall use standard 91/2" x 11" fan fold paper.

C. Provide a local desktop style uninterruptible power supply (UPS) unit to supply power to the printer. UPS shall be sized to operate the printer in normal use for 24 hours. UPS unit shall be APC, Best or approved equal.

D. Provide metal stand, with integral paper rack, for printer.

2.14 FIRE-ALARM GRAPHIC ANNUNCIATOR PANEL

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Edwards; Carrier Global Corporation.
2. Gamewell-FCI; Honeywell International, Inc.
3. Harrington Signal, Inc.
4. Potter Electric Signal Company, LLC.
5. Siemens Industry, Inc., Building Technologies Division.
6. The H.R. Kirkland Company, Inc.

B. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

2. General Characteristics:

a. Graphic Annunciator Panel: Enclosure shall be flush mounted where indicated on the drawings. All graphic information shall be white photo-emulsion factory-applied to 1/4" smoke color Plexiglas face at the time of manufacture. The

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annunciator face shall be protected by a 1/10" clear Plexiglas enclosed by an architectural color as selected by Architect anodized extruded aluminum frame.

b. The annunciator shall include a trouble Sonalert.

c. The graphic annunciator shall provide an outline of the entire building (plan, elevation or isometric view as appropriate to the facility and approved by the Authority Having Jurisdiction), with major corridors, stairways, elevator shafts and lobbies, building primary and secondary entrances and exits and major architectural features shown. Provide indication for location of sprinkler system Fire Department Siamese connection, standpipes and standpipe control valves; fire pump. Indicate location of Electric Service and emergency generators. The building outline shall be oriented to the viewing direction. Provide north arrow and a "You Are Here" indicator. The building shall be divided into zones, generally as follows:

- Level One Area A
- Level One Area B
- Level One Area C
- Leve Two Area A
- Level Two Area B
- Level Two Area C
- Level Three Area A
- Level Three Area B
- Level Three Area C

d. Backlit LED indicators shall be provided within each zone for alarm (red) and trouble (yellow) for each of the following:

1) Manual pull stations
2) Automatic detectors
3) Sprinkler flow
4) Duct smoke detector
5) Carbon Monoxide Detector (blue LED/supervisory only
6) Sprinkler valve position (yellow LED/supervisory only)
7) Kitchen hood fire suppression system

e. Provide backlit LED indicator(s) for each elevator or group of elevators to indicate activation of the following:

1) Elevator Top of Shaft smoke detector
2) Elevator Shaft heat detector
3) Elevator Control Room smoke detector
4) Elevator Control Room heat detector
5) Elevator Pit smoke detector

f. Provide an LCD display unit, set flush in the face of the annunciator panel, to mimic the display at the Fire Alarm Control Panel.

g. Backlit LED indicators shall be provided on the annunciator for the following functions:

1) System power on (green)

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2) System alarm (red)
3) System trouble (yellow)
4) Supervisory condition (yellow)
5) Emergency generator running (green) for each generator
6) Emergency generator fault (yellow) for each generator
7) Fire pump controller power available (green)
8) Fire pump running (green)
9) Fire pump controller power loss (yellow)
10) Fire pump controller phase reversal (yellow)

h. Key operated switches shall be provided on the face of the annunciator for the following controls:

1) Trouble silence
2) Fire pump start
3) Provide a remote key operated start switch for each emergency generator. Activation of this switch shall cause the emergency generator to start regardless of status of utility power.

i. Provide guarded pushbuttons on the graphic annunciator for shut-down of building HVAC systems in accordance with NFPA-90A, paragraph 4.2. Activation of the pushbutton shall cause the building air handling systems to be shut down. Refer to schedules of air handling systems and equipment on the Mechanical Drawings to determine which systems or equipment are to be shut-down. Provide one switch per air handling system for shut-down of building air handling equipment.

j. The graphic annunciator shall be UL listed.

k. Provide Quality Engraving and Design QED Series graphic annunciator with custom graphics and controls as specified herein.

l. The annunciator shall be a minimum of 24" x 30". Provide larger or multiple panel annunciators where required to provide all specified or required indications.

m. The graphic annunciator panel shall be approved by the Authority Having Jurisdiction prior to fabrication. Make submission of annunciator to the Authority Having Jurisdiction for their review and approval. All costs for review by the AHJ shall be included in the bid.

n. Do not begin fabrication of the annunciator until the annunciator has been approved by the Authority Having Jurisdiction, and by the Engineer.

2.15 FIRE ALARM REMOTE ANNUNCIATOR PANEL

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Bosch Security Systems, Inc.

B. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

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2. General Characteristics:

a. Annunciator functions must match those of FACP for alarm, supervisory, and trouble indications. Manual switching functions must match those of FACP, including acknowledging, silencing, resetting, and testing.

1) Mounting: Flush cabinet, NEMA 250, Type 1.

b. Display Type and Functional Performance: Alphanumeric display and LED indicating lights must match those of FACP. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.16 EXISTING CAMPUS BUILDINGS FIRE ALARM REMOTE ANNUNCIATOR PANELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Bosch Security Systems, Inc.

B. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

2. General Characteristics:

a. Annunciator functions must match those of existing buildings FACP for alarm, supervisory, and trouble indications. Manual switching functions must match those of existing buildings FACP, including acknowledging, silencing, resetting, and testing.

1) Mounting: Surface cabinet, NEMA 250, Type 1. Provide one (1) consolidated panel to support all remote annunciator functions for the existing buildings.

b. Display Type and Functional Performance: Alphanumeric display and LED indicating lights must match those of existing buildings FACP. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.17 FIRE-ALARM ADDRESSABLE INTERFACE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Silent Knight; Honeywell International, Inc. (Basis of Design)
2. Gamewell-FCI; Honeywell International, Inc.
3. Notifier; Honeywell International, Inc.
4. Edwards; Carrier Global Corporation.

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B. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

2. General Characteristics:

a. Include address-setting means on module.
b. Store internal identifying code for control panel use to identify module type.
c. Listed for controlling HVAC fan motor controllers.
d. Monitor Module: Microelectronic module providing system address for alarm-initiating devices for wired applications with normally open contacts.
e. Integral Relay: Capable of providing direct signal to circuit-breaker shunt trip for power shutdown.

1) Allow control panel to switch relay contacts on command.
2) Have minimum of two normally open and two normally closed contacts available for field wiring.

f. Control Module:

1) Operate notification devices.
2) Operate solenoids for use in sprinkler service.

2.18 DIGITAL ALARM COMMUNICATOR TRANSMITTERS (DACTs)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bosch Security Systems, Inc.
2. Edwards; Carrier Global Corporation.
3. Gamewell-FCI; Honeywell International, Inc.
4. Potter Electric Signal Company, LLC.

B. Performance Criteria:

1. Regulatory Requirements:

a. NFPA 72.

2. General Characteristics:

a. DACT must be acceptable to remote central station and must be listed for fire-alarm use.
b. Functional Performance: Unit must receive alarm, supervisory, or trouble signal from FACP and automatically capture two telephone line(s) and dial preset number for remote central station. When contact is made with central station(s), signals must be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter must initiate local trouble signal and transmit signal indicating

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loss of telephone line to remote alarm receiving station over remaining line. Transmitter must automatically report telephone service restoration to central station. If service is lost on both telephone lines, transmitter must initiate local trouble signal.

c. Local functions and display at DACT must include the following:

1) Verification that both telephone lines are available.
2) Programming device.
3) LED display.
4) Manual test report function and manual transmission clear indication.
5) Communications failure with central station or FACP.

d. Digital data transmission must include the following:

1) Address of alarm-initiating device.
2) Address of supervisory signal.
3) Address of trouble-initiating device.
4) Loss of ac supply.
5) Loss of power.
6) Low battery.
7) Abnormal test signal.
8) Communication bus failure.

e. Secondary Power: Integral rechargeable battery and automatic charger.
f. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Preinstallation Testing: Perform verification of functionality of installed components of existing system prior to starting work. Document equipment or components not functioning as designed.

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B. Protection of In-Place Conditions: Protect devices during construction unless devices are placed in service to protect facility during construction.

3.3 INSTALLATION OF EQUIPMENT

A. Comply with NECA 305, NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before other trades have completed cleanup must be replaced.
2. Devices installed, but not yet placed, in service must be protected from construction dust, debris, dirt, moisture, and damage in accordance with manufacturer's written storage instructions.

B. Install wall-mounted equipment, with tops of cabinets not more than 78 inch above finished floor.

C. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in normal path of egress within 60 inch of exit doorway.
2. Mount manual fire-alarm box on background of contrasting color.
3. Operable part of manual fire-alarm box must be between 42 and 48 inch above floor level. Devices must be mounted at same height unless otherwise indicated.

D. Smoke- and Heat-Detector Spacing:

1. Comply with "Smoke-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with "Heat-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing must not exceed 30 ft.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas must be determined in accordance with Annex A in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inch from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inch from lighting fixture and not directly above pendant mounted or indirect lighting.

E. Install cover on each smoke detector that is not placed in service during construction. Cover must remain in place except during system testing. Remove cover prior to system turnover.

F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend full width of duct. Tubes more than 36 inch long must be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

G. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

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H. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within dwelling or suite, they must be connected so that operation of smoke alarm causes alarm in smoke alarms to sound.

I. Remote Status and Alarm Indicators: Install in visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

J. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inch below ceiling. Install devices at same height unless otherwise indicated.

K. Device Location-Indicating Lights: Locate in public space near device they monitor.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate must be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate must be laminated acrylic or melamine plastic signs with black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.6 WIRING INSTALLATION

A. All pathways above ceilings in corridors or between floors shall be installed in EMT.

B. Install all fire alarm and detection system wiring in metal raceway as specified in Division 26 Section “Basic Electrical Materials and Methods.” No wiring other than that directly associated with the fire alarm or auxiliary functions shall be permitted in the fire alarm conduits. All low

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voltage fire alarm system wiring serving fire alarm system devices in finished rooms or spaces shall be metal clad cable type FPLP with red colored armor specifically designed and manufactured for fire alarm use. Provide plenum rated cables specifically designed and manufactured for fire alarm use where required. Cables may be run exposed above lay-in ceilings. Wiring shall be UL listed as suitable for use in air handling plenums. Wiring shall be fastened with approved nylon wire ties to the building structure. Cables shall not lay on or be attached to any temperature control tubing, mechanical piping or ductwork, other conduits or on the ceiling. Cables that penetrate or run within masonry walls and all runs where exposed in unfinished rooms or spaces shall be run in 3/4" conduit or other raceway system as specified in 26 05 33.13 – Conduits for Electrical Systems. All 120 volt wiring shall be run in conduit.

C. All wiring between fire alarm equipment panels in non-rated spaces shall be type CI cable.

D. Exposed EMT must be painted red enamel.

E. Paint all junction boxes and covers serving fire alarm circuits RED, and stencil covers with wording “Fire Alarm.”

F. Color Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use separate color codes for alarm initiating circuits, supervisory circuits, audible alarm indicating circuits and visual alarm indicating circuits. All conductors in conduit containing more than one wire shall be labeled on each end with "E-Z Markers" or equivalent.

G. Minimum wire size: No. 18 AWG solid copper for initiation and annunciator circuits: No. 14 AWG solid copper for indicating circuits: No. 12 AWG solid copper for 120 volt circuits.

H. Splices and Cable Taps: Wiring splices are to be avoided to the extent possible. Transposing or changing color coding of wires shall not be permitted. Where splices are required, use numbered terminal strips in junction, pull or outlet boxes, cabinets, or equipment enclosures where any circuit tap is made.

I. Wiring Within Enclosures: Install conductors parallel with or at right angles to the sides and back of the enclosure. Bundle, lace, and train the conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the wiring diagrams of the system. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors. All controls, function switches, and other panel devices shall be clearly labeled on all equipment panels.

J. Risers: Install at least 2 vertical cable risers to serve the fire alarm system. Fire alarm risers shall be installed in rigid conduit, no matter which wiring method is specified above for device connections. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signal from other floors or zones.

3.7 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08. Connect hardware and devices to fire-alarm system.

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1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with supervised interface device to the following devices and systems. Install interface device less than 36 inch from device controlled. Make addressable confirmation connection when such feedback is available at device or system being controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Magnetically held-open doors.
3. Electronically locked doors and access gates.
4. Alarm-initiating connection to elevator recall system and components.
5. Alarm-initiating connection to activate emergency lighting control.
6. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
7. Supervisory connections at valve supervisory switches.
8. Supervisory connections at elevator shunt-trip breaker.
9. Data communication circuits for connection to building management system.
10. Data communication circuits for connection to mass notification system.
11. Supervisory connections at fire-extinguisher locations.
12. Supervisory connections at fire-pump power failure including dead-phase or phase-reversal condition.
13. Supervisory connections at fire-pump engine control panel.

3.8 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 27.

B. Install framed instructions in location visible from FACP.

3.9 GROUNDING

A. Ground FACP and associated circuits in accordance with Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Ground shielded cables at control panel location only. Insulate shield at device location.

3.10 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Administrant for Tests and Inspections:

1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

C. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

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a. Inspection must be based on completed record Drawings and system documentation that is required by "Completion Documents, Preparation" table in "Documentation" section of "Fundamentals" chapter in NFPA 72.
b. Comply with "Visual Inspection Frequencies" table in "Inspection" section of "Inspection, Testing and Maintenance" chapter in NFPA 72; retain "Initial/Reacceptance" column and list only installed components.

2. System Testing: Comply with "Test Methods" table in "Testing" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for public operating mode in accordance with manufacturer's written instructions. Perform test using portable sound-level meter complying with Type 2 requirements in ASA S1.4 Part 1/IEC 61672-1.
4. Test audible appliances for private operating mode in accordance with manufacturer's written instructions.
5. Test visible appliances for public operating mode in accordance with manufacturer's written instructions.
6. Factory-authorized service representative must prepare "Fire Alarm System Record of Completion" in "Documentation" section of "Fundamentals" chapter in NFPA 72 and "Inspection and Testing Form" in "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

H. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system. Provide video recording of training to Owner.

3.12 MAINTENANCE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service must include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

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1. Include visual inspections in accordance with "Visual Inspection Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in "Test Methods" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per "Testing Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
4. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

END OF SECTION 28 46 21.11

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SECTION 31 00 00

EARTHWORK

PART 1 - GENERAL

1.1 DESCRIPTION

A. Earthwork includes: clearing, compaction, embankment, excavation, filling and grading, grubbing & stripping of topsoil.

B. The extent of earthwork is shown on the drawing.
1. Remove shrubs, trees, grass or obstructions which interfere with new construction and are noted to be removed per drawings. Preparation of subgrade for slabs, pavements, and foundations are also included as part of this work.

1.2 QUALITY ASSURANCE

A. Codes and Standards: Perform excavation work in compliance with applicable requirements of governing authorities having jurisdiction.

B. Provide soil testing and inspection service. Inspection agency selected and paid by contractor subject to approval of the Engineer.

1.3 FIELD QUALITY CONTROL

A. Quality Control Testing During Construction: Testing agency will inspect and Engineer will approve subgrades and fill layers before further construction work is performed thereon.

B. If, based on reports of Testing Agency and inspection, subgrade or fills which have been placed are below specified density, provide additional compaction and testing at no additional expense.

1.4 JOB CONDITIONS

A. Existing Utilities: Locate existing underground utilities in the areas of work.
1. Should uncharged or incorrectly charged piping or other utilities be encountered during excavation, consult the Owner immediately for directions as to proceed.
2. Contact "Miss Utility" and Owner for assistance in locating existing utilities.
3. Private utility location will be required to locate existing utilities.

B. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights. Operate warning lights during hours from dusk to dawn each day and as otherwise required.
1. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

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1.5 RELATED WORK SPECIFIED ELSEWHERE

Erosion & Sediment Control: Section 31 25 00

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. Subgrade Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, crushed slag, natural or crushed sand, as acceptable to the Owner.

B. Backfill and Fill Materials: Provide acceptable soil materials for backfill and fill from borrow, or on site stockpile, free of clay, rock, or gravel larger than 1" in any dimension, debris, waste, frozen materials, organic and other deleterious matter. Material to be in accord with governing jurisdiction and specifications: Delaware Standard Specifications for Road and Bridge Construction, June 2022, and all subsequent amendments thereof. DELDOT Type C shall be used unless otherwise indicated.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the areas and conditions under which excavating, filling and grading are to be performed and determine suitability of stockpiled soil for use as backfill and fill material. Do not proceed with the work until unsatisfactory conditions have been corrected and accepted by the Engineer.

B. Soil Bearing Testing
1. The Contractor shall be responsible for testing of the available soil bearing capacity. He shall arrange for such testing by an independent testing agency approved by the Engineer or Architect, the following tests shall be performed:
   a. Minimum one (1) three foot deep penetrometer test and subsequent bearing capacity evaluation per 3,000 S.F. of structure footprint.
2. The Contractor shall secure the necessary proctor tests and one field density test for every 50 CY of backfill material used for structures and embankments. A minimum of two field density tests per structure or embankment will be required.
3. The Engineer may request the necessary proctor tests and one compaction test per 100 L.F. section of backfilled trenches at any time during backfilling operations or upon completion of the backfill operations.

3.2. EXCAVATION

A. Excavation consists of removal and disposal of material encountered when establishing required grade elevations.

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B. Earth excavation consists of removal and disposal of pavements and other obstructions visible on ground surface.

C. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Owner. Under footings, foundation bases or slabs fill unauthorized excavation by extending the indicated bottom elevation of the footing or base to the excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position, only when acceptable to the Owner. Elsewhere, backfill and compact unauthorized excavation as specified for authorized excavations of same classification, unless otherwise directed by the Owner. Payment will not be made to the contractor for filling unauthorized excavation.

D. Stability of Excavations: Slope side of excavation to comply with local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible either because of space restrictions or stability of material excavated.
1. Maintain sides and slopes of excavations in a safe condition until completion of backfilling.

E. Shoring and Bracing: Provide materials for shoring and bracing, such as sheet piling, uprights, stringers and crossbraces, in good serviceable condition.
1. Provide minimum requirements for trench shoring and bracing to comply with local codes and authorities having jurisdiction.
2. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Carry down shoring and bracing as excavation progresses.

F. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.
1. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.
2. Convey water removed from excavations and rain water to collecting or run-off areas. Provide and maintain temporary drainage ditches and other diversions outside excavation limits for each structure. Comply with applicable sediment control measures. Do not use trench excavations as temporary drainage ditches.
3. Dewatering for the structures and pipelines shall commence when groundwater is first encountered and shall be continued until such time as backfill has been completed. No concrete or pipes shall be laid in water nor shall water be allowed to rise over them until the concrete or mortar has set at least eight (8) hours. Groundwater shall not be allowed to rise around the pipe until the trench is backfilled.
4. The Contractor shall dispose of the water from the work in a suitable manner without damage to adjacent property. No water shall be drained into work built or under construction without prior consent of the Engineer. Water shall be disposed of in such a manner as not to be a menace to the Public Health. Water shall be piped to the nearest point of the municipal storm drainage system as directed by the Engineer. Contractor to provide necessary traffic control to

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maintain temporary piping. No discharge to the sanitary sewer system shall be allowed.

5. In the event the Contractor's dewatering operations affect any water supplies within the project area, the Contractor shall take whatever steps that are required to provide uninterrupted water service.
6. The Contractor shall remove any siltation deposits in storm sewer systems, resulting from his dewatering or construction operations. He shall also be responsible for conveyance of dewatering flows and for erosion and sediment control.

G. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage.
1. Locate and retain soil materials away from edge of excavations.
2. Dispose of excess and/or unsatisfactory soil material and waste materials as specified hereinafter.

H. Excavation for Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10', and extending a sufficient distance from footings and foundations to permit placing and removal of concrete form work, installation of services, other construction required, and for inspection. In excavating for footings and foundations, take care not to disturb bottom of excavation.
Excavate by hand to final grade just before concrete is placed. Trim bottoms to required lines and grades to leave solid base to receive concrete.

I. Excavation for Pavements: Cut surface under pavements to comply with cross sections, elevations and grades as shown.

J. Removal of Unsatisfactory Soil Materials: Excavate unsatisfactory soil materials encountered that extend below required elevations, to additional depth directed by the Engineer. Unsatisfactory material is defined as clay, silt, etc. which would not, in the Engineer's opinion, provide adequate strength and would not compact properly. Unsatisfactory material shall be removed from the site.

3.3 COMPACTION

A. General: Control soil compaction during construction providing minimum percentage of density specified for each area classification.

B. Percentage of Maximum Density Requirements: Provide not less than the following percentages of maximum density of soil material compacted at -2 to +2 percent of optimum moisture content, as determined by ASTM D1557, for the actual density of each layer of soil material-in-place.
1. Building Slabs and Steps: Compact top 12" of subgrade, place material in 8" loose layers and compact each layer of backfill or fill material to 95% maximum density.
2. Lawn or Unpaved Areas: Compact top 6" of subgrade, place and compact each layer of backfill or fill material to 90% maximum density.
3. Walkways: Compact top 6" of subgrade. Place material in 8" loose layers and compact each layer of backfill or fill material at 95% maximum density.
4. Pavements: Compact top 12" of subgrade, place material in 8" loose layers and compact each layer of backfill or fill material to 95% maximum density.

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5. Pipeline: Backfill in 8" loose layers with mechanical compaction, to 95% maximum density in traffic areas and 90% in non-traffic areas.
6. Backfill in demolition areas: Backfill in 8" loose layers with mechanical compaction to 95% maximum density.
7. Embankments: Place material in 8" loose layers with mechanical compaction to 95% maximum density.

C. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade, or layer of soil material.

3.4 BACKFILL AND FILL

A. General: Place satisfactory excavated, borrow or stockpiled material in layers to required subgrade elevations.

B. Backfill excavations promptly as work permits, but not until completion of the following:
1. Acceptance by Engineer of construction below finish grade including, where applicable, dampproofing, and perimeter insulation.
2. Inspection, testing, approval, and recording locations of underground utilities.
3. Removal of concrete formwork.
4. Removal of shoring and bracing, and backfilling of voids with satisfactory materials.
5. Removal of trash and debris.

C. Ground Surface Preparation: Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to placement of fills. Plow, strip or break-up sloped surfaces steeper than 1 vertical to 4 horizontal so that fill material will bond with existing surface.
1. When existing ground surface has a density less than that specified under "Compaction" for the particular area classification, break up the ground surface, pulverize, moisture-condition to the optimum moisture content and compact to required depth and percentage of maximum density.

D. Placement and Compaction: Place backfill and fill materials in layers not more than 8" in loose depth. Before compaction, moisten or aerate each layer as necessary to provide the optimum moisture content. Compact each layer to required percentage of maximum density for each area classification. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
1. Place backfill and fill materials evenly adjacent to structures, to required elevations. Take care to prevent wedging action of backfill against structures by carrying the material uniformly around structure to approximately same elevation in each lift.

3.5 GRADING

A. General: Uniformly grade areas within limits of grading under this section, including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are shown, or between such points and existing grades.

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B. Grading Outside Structures: Grade areas adjacent to structures to drain away from structures and to prevent ponding. Finish surfaces free from irregular surface changes, and as follows:

1. Grassed Areas: Finish areas to receive topsoil to within not more than 0.10' above or below the required subgrade elevations.
2. Walks: Shape surface of areas under walks to line, grade and cross-section, with finish surface not more than 0.10' above or below the required subgrade elevations.
3. Pavements: Shape surface of areas under pavement to line, grade and cross-section, with finish surface not more than 0.10' above or below the required subgrade elevation.

C. Grading Surface of Fill Under Building Slabs: Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grades within a tolerance of 0.2'.

D. Compaction: After grading, compact subgrade surfaces to the depth and percentage of maximum density for each area classification.

3.6 MAINTENANCE

A. Protection of Graded Areas: Protect newly graded areas from traffic and erosion, and keep free of trash and debris.

1. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.

B. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, re-shape, and compact to required density prior to further construction.

END OF SECTION

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SECTION 31 05 13

SOILS FOR EARTHWORK

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Subsoil.
2. Topsoil.

1.2 SUBMITTALS

A. Product Data:

1. Subsoil.
2. Topsoil.

B. Samples: To be taken by testing agency.

C. Source Quality-Control Reports: For subsoil and topsoil materials.

1.3 SUSTAINABLE DESIGN SUBMITTALS

A. Product Certificates: For the source and origin for salvaged and reused subsoil and topsoil materials.

B. Product Certificates: For the source for regional subsoil and topsoil materials and distance from Project Site.

1.4 QUALITY ASSURANCE

A. Furnish each subsoil and topsoil material from single source throughout Work.

B. Perform Work according to ASTM standards.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Perform Work according to:

1. The State of Delaware Department of Transportation standards.
2. The Town of Smyrna standards.
3. DNREC Sediment and Stormwater standards.

2.2 SUBSOIL

A. Type S2 Ordinary Borrow:

1. Borrow Type F per DelDOT Standards & Specifications.

B. Type S2-a Special Borrow:

1. Borrow Type C per DelDOT Standards and Specifications.

C. Type S2-b Pipe Bedding Material and Drainage Layer:

1. Borrow Type C per DelDOT Standards and Specifications.

D. Type S2-d Structural Fill:

Borrow Type C per DelDOT Standards and Specifications.

2.3 TOPSOIL

A. Type S3: Comply with DelDOT standards.

2.4 SOURCE QUALITY CONTROL

A. Testing and Analysis:

1. Subsoil Material: Comply with ASTM D1557.
2. Topsoil Material: Comply with ASTM D1557.
3. If tests indicate materials do not meet specified requirements, change material and retest.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions for compliance with requirements for maximum moisture content, installation tolerances, and other conditions affecting performance of the Work.

3.2 INSTALLATION OF SUBSOIL AND TOPSOIL

A. Excavation:

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1. Excavate subsoil and topsoil from designated areas.
2. Strip topsoil to full depth of topsoil in designated areas.
3. Remove excess excavated materials, subsoil, and topsoil not intended for reuse from Site.
4. Remove excavated materials not meeting requirements for subsoil and topsoil materials from Site.

B. Stockpiling:

1. Stockpile excavated material meeting requirements for subsoil and topsoil materials.
2. Stockpile materials on Site at locations as indicated.
3. Stockpile in sufficient quantities to meet Project schedule and requirements.
4. Separate differing materials with dividers or stockpile apart to prevent intermixing of soil types or contamination.
5. Stockpile topsoil maximum 8 feet (2.5 m) high.
6. Direct surface water away from stockpile to prevent erosion or deterioration of materials.
7. Stockpile unsuitable materials on impervious material and cover to prevent erosion and leaching until they are disposed.

3.3 CLEANING

A. Stockpile:

1. Remove stockpile and leave area in clean and neat condition.

a. Grade Site surface to prevent freestanding surface water.

END OF SECTION

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SECTION 31 05 16

AGGREGATES FOR EARTHWORK

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Coarse aggregate.
2. Fine aggregate.

1.2 SUBMITTALS

A. Product Data:

1. Fine aggregate.
2. Coarse aggregate.
3. Submit name of imported materials source.

B. Source Quality-Control Reports: For fine- and coarse-aggregate materials.

1.3 QUALITY ASSURANCE

A. Furnish each coarse- and fine-aggregate material from single source throughout Work.

B. Perform Work according to DelDOT standards.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Perform Work according to:

1. The State of Delaware Department of Transportation Standards.
2. The Town of Smyrna standards.
3. DNREC Sediment and Stormwater Standards.

2.2 COARSE AGGREGATE

A. Type A3 Crushed Stone:

1. GABC Type B per DelDOT standards.

2.3 SOURCE QUALITY CONTROL

A. Testing and Analysis:

1. Coarse-Aggregate Material: Comply with ASTM D1457.
2. If tests indicate materials do not meet specified requirements, change material and retest.

B. Owner or Authority Inspection:

1. Make coarse aggregate available for inspection at source prior to loading for shipment.
2. Notify Owner or Authority at least seven days before inspection is allowed.

C. Owner or Authority Witnessing:

1. Allow witnessing of source testing at supplier's facility.
2. Notify Owner or Authority at least seven days before tests are scheduled.

D. Certificate of Compliance:

1. If supplier is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at source conforms to Contract Documents.
2. Specified source tests are not required for Work performed by approved supplier.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions for compliance with requirements for maximum moisture content, installation tolerances and other conditions affecting performance of the Work.

3.2 CLEANING

A. Stockpile:

1. Remove stockpile and leave area in clean and neat condition.

a. Grade Site surface to prevent freestanding surface water.

END OF SECTION

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SECTION 31 05 19.13

GEOTEXTILES FOR EARTHWORK

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Woven turf reinforcement mats (TRMs).
2. Nonwoven geotextile materials.
3. Woven geotextiles for erosion control.
4. Woven geotextiles for paved and unpaved roads.

1.2 SUBMITTALS

A. Product Data: For the following:

1. Woven turf reinforcement mats (TRMs).
2. Nonwoven geotextile materials.
3. Woven geotextiles for erosion control.
4. Woven geotextiles for paved and unpaved roads.
5. Submit manufacturer information including tensile strength, elongation, thickness, UV resistance, and other material specifications.
6. Submit testing agency compliance with the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI-LAP).

B. Shop Drawings:

1. Indicate fabric layout, seam locations, and overlap details in installation drawings.
2. Seaming Procedures: When a field-sewn seam is required, use high-strength polypropylene or polyester threads. Do not use nylon thread. Comply with ASTM D4884/D4884M. Use the following guidelines for seams sewn in the field:
    a. Provide a minimum length of 3 feet of the sewn seam for sampling by the Architect/Engineer prior to geotextile installation.
    b. Provide sample using the same equipment and procedures utilized in production of the geotextile.
    c. Submit the seam assembly description, including the seam type, stitch type, sewing thread, and stitch density, along with the sample of the seam.
3. Signed and sealed by the qualified professional engineer responsible for their preparation.

C. Samples:

1. Submit two (2) samples, 24" x 3' long, for each type and weight of geotextile used on Project, illustrating field seaming method.

D. Source Quality-Control Reports: For TRMs and woven and nonwoven geotextiles.

E. Qualifications Statements: For manufacturer, installer, and testing agency.

F. Manufacturer's Approval: For installer.

G. Provide shop inspection and testing of completed assembly. Comply with ASTM D4759.

1.3 SUSTAINABLE DESIGN SUBMITTALS

A. Product Certificates: For the source for regional TRMs and woven and nonwoven geotextile materials and distance from Project Site.

B. Product Certificates: For recycled geotextile material content for recycled content products.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of geotextile materials, including placement depth.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Materials:

1. Furnish two (2) seam repair kits.
2. Furnish 3 sq. yd. of geotextile material.

B. Tools: Furnish special tools and other devices required for Owner to maintain and repair geotextile material.

1.6 QUALITY ASSURANCE

A. Manufacturers Qualifications: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.

B. Installers Qualifications: Company specializing in performing Work of this Section with minimum three years' documented experience and approved by manufacturer.

C. Licensed Professionals Qualifications: Professional engineer experienced in design of specified Work and licensed in State of Delaware.

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1.7 DELIVERY, STORAGE, AND HANDLING

A. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

B. Comply with ASTM D4873.

C. Store materials according to manufacturer instructions.

D. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Provide additional protection according to manufacturer instructions.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Perform Work according to:

1. The State of Delaware Department of Transportation standards.
2. The Town of Smyrna standards.
3. DNREC Sediment and Stormwater standards.

B. Ensure that terminology incorporated herein complies with ASTM D4439.

2.2 WOVEN TURF REINFORCEMENT MATS (TRMS)

A. Provide turf reinforcement mats (TRMs) with sufficient thickness, optimum open area, and three-dimensionality for effective erosion control and vegetation reinforcement against high flow-induced shear forces. Provide material that has high interlock and reinforcement capacity with both soil and root systems and is designed for erosion control applications on steep slopes and vegetated waterways.

B. Manufacturers:

1. Propex Operating Company, LLC.
2. Contech Engineered Solutions LLC.
3. Nilex, Inc.
4. Approved by DNREC.

C. Furnish materials according to DNREC Sediment and Stormwater standards.

D. Non-biodegradable, UV-resistant, woven geotextile fabric.

E. Edges: Selvaged or finished to prevent separation of outer material.

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F. Calendar such that yarns will retain relative positions.

G. Performance and Design Criteria:

1. Comply with AASHTO M 288.
2. Mass per Unit Area:

   a. 14.0 oz./sq. yd (475 g/sq. m).
   b. Comply with ASTM D6566.

3. Thickness:

   a. 0.40 inch (10.2 mm).
   b. Comply with ASTM D6525/D6525M.

4. Light Penetration:

   a. Light Passing: 75 percent.
   b. Comply with ASTM D6567.

5. Tensile Strength (Grab):

   a. 4,000 by 3,000 lb./ft (58.4 by 43.8 kN/m).
   b. Comply with ASTM D6818.

6. Maximum Elongation:

   a. 40 by 35 percent.
   b. Comply with ASTM D6818.

7. Resiliency:

   a. 80 percent.
   b. Comply with ASTM D6524/D6524M.

8. Average Flexibility:

   a. 0.534 IP (166,154 mg-cm).
   b. Comply with ASTM D6575/D6575M.

9. UV Resistance at 6,000 Hours:

   a. Strength Retention: 90 percent.
   b. Comply with ASTM D4355/D4355M.

10. Velocity Performance:

    a. Velocity (Vegetated): 25 fps (7.6 m/s).

11. Seeding Emergence:

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a. 296 percent.
b. Comply with ASTM D7322.

2.3 NONWOVEN GEOTEXTILE MATERIALS

A. Provide nonwoven geotextile that meets AASHTO M 288 Class 3 requirements for subsurface drainage, separation, and stabilization. Provide multipurpose fabrics with a felt-like appearance. The main functions for these products are filtration and separation. The most common nonwoven is a needle-punched product.

B. Manufacturers:

1. TENCATE Mirafi.
2. Carthage Mills.
3. Hanes Geo Components.
4. DNREC approved.

C. Furnish materials according to DNREC standards.

D. Non-biodegradable, UV-resistant, nonwoven geotextile fabric.

E. Edges: Selvaged or finished to prevent separation of outer material.

F. Calendar such that yarns will retain relative positions.

G. Performance and Design Criteria:

1. Minimum Unseamed Sheet Width: 12.5 by 15 feet (3.8 by 4.5 m).
2. Nominal Weight: 4.2 oz./sq. yd (142 g/sq. m).
3. Apparent Opening Size (AOS):

a. No 70 U.S. standard sieve size (0.212 mm).
b. Comply with ASTM D4751.

4. Water Permittivity: 1.70 Hz per second, minimum average roll value.
5. Water Flow Rate:

a. 135 gpm/sq. ft. (5 500 lpm/sq. m), minimum average roll value.
b. Comply with ASTM D4491/D4491M.

6. Grab Tensile Strength:

a. 120 lbf (0.534 kN), minimum average roll value.
b. Comply with ASTM D4632/D4632M.

7. Elongation:

a. 50 percent, minimum average roll value.
b. Comply with ASTM D4632/D4632M.

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8. Trapezoidal Tear Strength:

    a. 50 lbf (223 kN) minimum average roll value.
    b. Comply with ASTM D4533/D4533M.

9. Puncture Strength:

    a. 310 lbf (1 380 N) minimum average roll value.
    b. Comply with ASTM D6241.

10. UV Resistance at 500 Hours:

    a. Strength Retention: 70 percent.
    b. Comply with ASTM D4355/D4355M.

2.4 WOVEN GEOTEXTILES FOR EROSION CONTROL

A. Provide woven geotextile that meets AASHTO M 288 Class 2 and 3 (less than 15 percent fines) for permanent erosion control and subsurface drainage. Provide woven monofilament filtration geotextile made of 100 percent polypropylene yarns. Provide woven geotextile with opening area of 4 to 6 percent to provide excellent hydraulic properties and reduce clogging.

B. Manufacturers:

1. TENCATE Mirafi.
2. Carthage Mills.
3. US Fabrics.
4. DNREC approved list.

C. Furnish materials according to DNREC Sediment and Stormwater standards.

D. Non-biodegradable, UV-resistant, woven geotextile fabric.

E. Edges: Selvaged or finished to prevent separation of outer material.

F. Calendar such that yarns will retain relative positions.

G. Performance and Design Criteria:

1. Roll Dimension: 12.5 by 300 feet (3.78 by 91 m)
2. Nominal Roll Weight: 176 lb (80 kg).
3. Apparent Opening Size (AOS):

    a. No. 70 U.S. standard sieve size (0.212 mm).
    b. Comply with ASTM D4751.

4. Water Permittivity: 0.28 Hz per second, minimum average roll value.
5. Water Flow Rate:

    a. 18 gpm/sq. ft. (733 lpm/sq. m), minimum average roll value.

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b. Comply with ASTM D4491/D4491M.

6. Grab Tensile Strength:

a. 370 by 250 lb. (1 647 by 1 113 N), minimum average roll value.
b. Comply with ASTM D4632/D4632M.

7. Elongation:

a. 15 percent, minimum average roll value.
b. Comply with ASTM D4632/D4632M.

8. Trapezoidal Tear Strength:

a. 100 by 60 lb. (445 by 267 N), minimum average roll value.
b. Comply with ASTM D4533/D4533M.

9. Puncture Strength:

a. 950 lb. (4 228 N), minimum average roll value.
b. Comply with ASTM D6241.

10. UV Resistance at 500 Hours:

a. Strength Retention: 90 percent.
b. Comply with ASTM D4355/D4355M.

11. Percent Open Area:

a. 4 percent.
b. Comply with Corps of Engineers (COE) - 02215.

2.5 WOVEN GEOTEXTILES FOR PAVED AND UNPAVED ROADS

A. Provide woven geotextile which meets AASHTO M 288 Class 1. Provide road fabric that separates and stabilizes materials. Provide flexible, porous geotextile placed between different materials so that both materials can either function properly or have improved functionality. Geotextile road fabrics prevent rutting and erosion, allowing water to flow through gravel or a thin layer of sediment to the soil and dirt underneath.

B. Manufacturers:

1. CHEROKEE Manufacturing.
2. One Clarion.
3. US Fabrics.
4. Pro Fabric Supply.
5. DNREC approved list.

C. Furnish materials according to DNREC Sediment & Stormwater standards.

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D. Non-biodegradable, UV-resistant, woven geotextile fabric.

E. Edges: **Selvaged or finished** to prevent separation of outer material.

F. Calendar such that yarns will retain relative positions.

G. Performance and Design Criteria:

1. Weight:

   a. 6.3 oz./sq. yd (214 g/sq. m).
   b. Comply with ASTM D5261.

2. Apparent Opening Size (AOS):

   a. No. 43 U.S. standard sieve size (0.425 mm).
   b. Comply with ASTM D4751.

3. Water Permittivity: [0.05 Hz] <Insert> per second, minimum average roll value.
4. Water Flow Rate:

   a. 4 gpm/sq. ft. (163 lpm/sq. m), minimum average roll value.
   b. Comply with ASTM D4491/D4491M.

5. Grab Tensile Strength:

   a. 315 lb. (1.4 kN), minimum average roll value.
   b. Comply with ASTM D4632/D4632M.

6. Grab Elongation:

   a. 15 percent, minimum average roll value.
   b. Comply with ASTM D4632/D4632M.

7. Trapezoidal Tear Strength:

   a. 120 lb. (0.533 kN), minimum average roll value.
   b. Comply with ASTM D4533/D4533M.

8. California Bearing Ratio (CBR) Puncture Strength:

   a. 1,000 lb. (4.45 kN), minimum average roll value.
   b. Comply with ASTM D6241.

9. UV Resistance at 500 Hours:

   a. Strength Retention: 70 percent.
   b. Comply with ASTM D4355/D4355M.

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2.6 ACCESSORIES

A. Sewing Thread:

1. Material: Polypropylene, Polyester or Kevlar.
2. Durability: Equal to or greater than durability of geotextile.

B. Securing Pins:

1. Material: Steel rods or bars.
2. Diameter: 3/16 inch (0.2 mm).
3. Minimum Length: 12 inches (300 mm).
4. Washers:

a. Material: Steel.
b. Outside Diameter: Minimum 1-1/2 inches (38 mm).
c. Inside Diameter: 1/4 inch (6 mm).
d. Thickness: 1/8 inch (3 mm).

C. Wire Staples:

1. Material: Steel.
2. Minimum Size: 10 gage (3.6 mm).
3. Minimum Length: 6 inches (150 mm).

2.7 SOURCE QUALITY CONTROL

A. Provide shop inspection and testing of completed assembly. Provide sampling of geosynthetics for testing in compliance with ASTM D4354.

B. Owner Inspection:

1. Make completed geotextile material available for inspection at manufacturer's factory prior to packaging for shipment.
2. Notify Owner at least seven days before inspection is allowed.

C. Owner Witnessing:

1. Allow witnessing of factory inspections and tests at manufacturer's test facility.
2. Notify Owner at least seven days before inspections and tests are scheduled.

D. Certificate of Compliance:

1. If manufacturer is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at manufacturer's facility conforms to Contract Documents and GAI-LAP.
2. Specified shop tests are not required for Work performed by approved manufacturer.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, with Applicator present, for compliance with requirements for maximum moisture content, installation tolerances, and other conditions affecting performance of the Work.

B. Verify that underlying surface is smooth and free of ruts or protrusions that could damage geotextile material.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Subgrade Material and Compaction Requirements: As specified in Section 31 23 16.13 – Trenching and 31 23 23 - Fill.

3.3 INSTALLATION OF GEOTEXTILES

A. Geotextile Material:

1. Lay and maintain smooth and free of tensile stresses, folds, wrinkles, or creases.
2. Ensure that material is in direct contact with subgrade.
3. Orientate with long dimension of each sheet parallel to direction of slope.
4. Minimum Unseamed Joints Overlap: 18 inches (450 mm).

B. Securement Pins:

1. Insert through geotextile midway between edges of overlaps and minimum 6 inches (150 mm) from free edges.
2. Minimum Spacing:

a. Slopes Steeper than 3 Horizontal on 1 Vertical: 24 inches (600 mm) o.c.
b. Slopes 3 Horizontal on 1 Vertical to 4 Horizontal on 1 Vertical: 3 feet (1 m) o.c.
c. Slopes Flatter than 4 Horizontal on 1 Vertical: 5 feet (1.5 m) o.c.

3. Ensure that washer bears against geotextile.

C. Seams:

1. Minimum Seamed Joints Overlap: 12 inches (300 mm) at longitudinal and transverse joints.
2. Seams across Slope: Lap upper panel over lower panel.
3. Sewn Seams:

a. Continuously sew seams on slopes steeper than 1 vertical on 3 horizontal.
b. Stitch Type: As recommended by geotextile manufacturer.

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c. Tie off thread at the end of each seam to prevent unraveling.

4. Thermal Seams:

a. As recommended by geotextile manufacturer.
b. Comply with ASTM D4886.

D. Penetrations: As recommended by geotextile manufacturer.

E. Repair Damaged Geotextiles:

1. Repair torn or damaged geotextile by placing patch of same type of geotextile over damaged area minimum of 12 inches (300 mm) beyond edge of damaged area and fasten as recommended by geotextile manufacturer.
2. Remove and replace geotextile rolls which cannot be repaired.

F. Fill and Cover:

1. Place fill to prevent tensile stress or wrinkles in geotextile.
2. Place fill from bottom of side-slopes upward.
3. Do not drop fill from height greater than 3 feet (1 m).

3.4 DEMONSTRATION

A. Manufacturer Services: Furnish services of manufacturer's representative experienced in installation of products furnished under this Section for not less than 1 day on Site for installation, field testing, and inspection.

B. Equipment Acceptance:

1. Adjust, repair, modify, or replace components failing to perform as specified.
2. Make final adjustments to equipment under direction of manufacturer's representative.

3.5 PROTECTION

A. Ballast: Adequate to prevent uplift of material by wind.

B. UV Exposure: Do not leave material uncovered for more than 14 days after installation.

C. Do not use staples or pins to hold geotextiles in place where located adjacent to other geosynthetic layers that could be damaged.

D. Do not operate equipment directly on top of geotextiles.

END OF SECTION

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SECTION 31 10 00

SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Removing surface debris.
2. Removing designated paving, curbs.
3. Removing designated trees, shrubs, and other plant life.
4. Removing abandoned utilities.
5. Excavating topsoil.

1.2 SUBMITTALS

A. Product Data: Herbicide; indicate compliance with applicable codes for environmental protection.

1.3 QUALITY ASSURANCE

A. Perform Work according to DelDOT, DNREC and Town of Smyrna standards.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify existing plant life designated to remain is tagged or identified.

B. Identify salvage area for placing removed materials.

3.2 PREPARATION

A. Call local utility line information service at 811 not less than three working days before performing Work.

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1. Request underground utilities to be located and marked within and surrounding construction areas.

B. Use private locators to augment Miss Utility.

3.3 PROTECTION

A. Locate, identify, and protect utilities indicated to remain from damage.

B. Protect bench marks, survey control points, and existing structures from damage or displacement.

3.4 CLEARING

A. Clear areas required for access to Site and execution of Work to minimum depth of 12 inches.

B. Remove trees and shrubs indicated. Remove stumps, main root ball, root system to depth of 12 inches.

C. Clear undergrowth and deadwood, without disturbing subsoil.

3.5 REMOVAL

A. Remove debris, rock, and extracted plant life from Site.

B. Partially remove paving, and curbs as indicated. Neatly saw cut edges at right angle to surface.

C. Remove abandoned utilities. Indicated removal termination point for underground utilities on record documents.

D. Continuously clean-up and remove waste materials from Site. Do not allow materials to accumulate on Site.

E. Do not burn or bury materials on Site. Leave Site in clean condition.

3.6 TOPSOIL EXCAVATION

A. Excavate topsoil from areas to be further excavated, relandscaped, or regraded, without mixing with foreign materials for use in finish grading.

B. Do not excavate wet topsoil.

C. Stockpile in area designated on Site to depth not exceeding 8 feet and protect from erosion. Stockpile material until disposal.

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D. Remove excess topsoil not intended for reuse from Site.

END OF SECTION

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SECTION 31 11 00

CLEARING AND GRUBBING

PART 1 - GENERAL

1.1 USE OF EXPLOSIVES

A. The use of explosives will not be permitted.

1.2 PROTECTION OF PERSONS AND PROPERTY

A. Clearing and grubbing operations shall be conducted in a manner that will ensure safety of persons and prevent damage to existing structures and utilities, construction in progress, trees, vegetation designated to remain standing including root damage, and other property.

PART 2 - PRODUCTS

2.1 FILL MATERIAL

A. Fill material needed for filling depressions shall be Delaware Department of Transportation Type C borrow material, in accordance with Section 209 or approved excavated material.

PART 3 - EXECUTION

3.1 CLEARING OPERATIONS

A. Clearing shall consist of the vegetation designated for removal, including rubbish occurring within the areas to be cleared. Clearing shall also include the complete removal and disposal of the tennis courts that obtrude, encroach upon, or otherwise obstruct the work.

3.2 GRUBBING OPERATIONS

A. The Contractor shall completely remove all debris protruding through the ground surface. This material shall be excavated and remove to a depth of not less than 12 inches below the surface level of the original ground.

3.3 FILLING DEPRESSIONS

A. Depressions resulting from grubbing operations shall be completely filled with fill material, unless further excavation or earthwork is indicated.

B. Prior to filling, subgrade surfaces of depressions shall be free of standing water, frost, or frozen material.

C. The Contractor shall place fill material in horizontal layers not to exceed 8 inches in loose depth. Each layer shall be compacted between -2 to +2 percent of the optimum moisture

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content and to 90% of maximum dry density outside of paving and 95% in areas of proposed paving, as determined by ASTM D1557. The density of soil-in-place shall be determined in accordance with ASTM D1556, Sand Cone Method or ASTM D2922, Nuclear Method. The surface of filled depressions shall be graded to meet adjacent proposed contours and to provide surface water drainage.

3.4 DISPOSAL OF CLEARED AND GRUBBED MATERIAL

A. Burning of materials on site will not be permitted.

B. Refuse from the clearing and grubbing operations shall be removed for disposal at no additional cost to the Owner. Costs of permits and fees for disposal shall be paid by the Contractor. The Contractor shall be responsible for compliance with federal, state, and local laws and regulations pertaining to the control of environmental pollution, building of fires, and other regulated practices in the disposal of cleared and grubbed materials.

END OF SECTION

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SECTION 31 23 00

EXCAVATION AND BACKFILL FOR PIPELINES AND STRUCTURES

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PART 1 - GENERAL

1.1 DESCRIPTION

A. The Contractor shall perform all excavation, backfilling grubbing and grading required for construction and installation of pipelines, structures and appurtenances. Excavation shall include removal of pavement, concrete, rock, earth and debris, regardless of character. Trenches and excavations shall be sheeted, shored and braced by the Contractor, as necessary to allow construction and provide safe working conditions. Additionally, the Contractor shall be responsible for maintaining a dry excavation by dewatering. He shall also locate, support and protect existing utilities and structures encountered in the work, provide traffic control, dispose of surplus and unsuitable excavated materials and restore backfilled areas to original condition or as required by the drawings and specifications. All backfilled and restored areas shall be maintained by the Contractor, in a proper condition, for the duration of the project.

B. The Contractor is responsible for direct or indirect damage to existing structures, pipelines, conduits, poles, wires and utilities of every description in the vicinity of his work whether above or below ground, or that may be encountered in trench or structure excavation. This responsibility shall include the cost of protection by sheeting, bracing, hand excavation, when warranted, and the expense to repair or replace any existing facility damaged directly or indirectly by construction activities under this contract, whether such facility is or is not shown on the drawings.

C. The Contractor shall verify the location, size and elevation of all existing utilities at the various points of connection and/or crossings prior to starting any work. Any discrepancies in locations or elevations shall be brought to the attention of the Engineer in order that the designs may be adjusted accordingly. Damages suffered or additional costs incurred by the Contractor as a result of his failure to conform to the requirements of this paragraph shall be the sole responsibility of the Contractor. Connections to existing utilities shall be made by the Contractor at such a time and in such a manner as the Engineer may direct, and the cost shall be included in the price bid for pipeline and structures, unless otherwise defined in the proposal.

D. Excavation and backfill, within an area where a State agency has jurisdiction, shall be done in accordance with requirements and provisions of the permits issued by the agencies for the construction within their respective rights-of-way. Such requirements and provisions, where applicable, shall take precedence and supersede the provisions of these specifications.

PART 2 - PRODUCTS

2.1 MATERIALS

No classification of excavated materials will be made. Excavation and trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the contract work, regardless of the type, character, composition, or condition thereof.

PART 3 - EXECUTION

3.1 PIPELINE TRENCH EXCAVATION

A. The Contractor shall excavate, maintain and backfill all excavation necessary for completing the work under the contract. Unless otherwise specified or approved, excavation shall be open cut. No extra compensation will be allowed for hand excavation and backfill necessary to complete the work or required by the Engineer.

B. Trenches shall be excavated to the necessary width and depth, as shown on the drawings and as required for the protective sheeting, pull boxes, etc. No extra compensation will be allowed for trenches wider than that detailed on the drawings.

C. The sides of the trenches shall be practically plumb and shall not be sloped unless approved in writing by the Engineer. Trench sides shall be supported or sheeted as required to protect pavement surfaces, curbing, utilities, etc., and required for safety. Safety regulations shall be as required by State safety codes and OSHA.

D. In paved areas, the Contractor shall remove the paving only as necessary for the excavation of the trench or as detailed. Pavement edges at the trench shall be saw cut neat and straight prior to the start of any excavation. Should the Contractor disturb or damage pavement for a greater width than detailed on the drawings or should pavement damage result from cave-ins, settlement, etc., Contractor shall replace such paving at his own expense. Saw cuts shall be carried out to the full depth of existing bituminous or concrete paving or combination thereof.

E. In non-paved areas strip surface vegetation and topsoil and place in stock piles which are separated from the trench excavated materials. Topsoil shall not be used for general trench refill.

F. The excavation of all trenches shall be fully completed at least twenty (20) feet in advance of pipe laying, unless otherwise authorized or directed. The Engineer may require the backfilling of open trench, over completed pipelines, or ahead of the pipe laying operation, if in his judgment such action is necessary, and the Contractor shall have no claim for extra compensation.

G. Should work be stopped for any reason and any excavation is left open for an unreasonable length of time, the Contractor shall refill the excavation at his own expense if so directed, by the Engineer or the Town Inspector. He shall not reopen the excavation until he is ready to complete the facility. Should the Contractor refuse or fail to refill any excavation completely within forty-eight (48) hours or immediately if it poses a safety hazard after a proper notice has been given by the Engineer or Town Inspector the Owner

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shall be authorized to do the work. The resulting expenses shall be deducted from monies due the Contractor.

H. The Contractor shall complete excavation as nearly as practicable to the lines of the pipeline to be installed as detailed. All cavities in the bottom of the trench shall be filled to the required level with compacted crushed stone or gravel. Unless the cavities have been made on direction of the Engineer and classified as "Excavation Below Subgrade" for unsuitable material, no extra compensation shall be due the Contractor

I. Excavated materials shall be graded, hauled, stored and protected as such material found suitable will be required for backfilling, repaving or other purposes. Material classified as unsuitable shall be disposed of by the Contractor at a location approved by the Engineer. Hauling of excavated materials for any purpose shall not entitle the Contractor to additional compensation. Only those excavated materials designated by the Owner shall become property of the Contractor.

J. All stockpiled materials shall be placed in such a way to prevent damage to the trench, structures, drainage areas or private property. Excavated materials shall not be placed on private property, unless written permission is obtained from the property Owner by the Contractor.

K. The Contractor shall remove, relocate, change or protect all structures including but not limited to signs, mailboxes, overhead and buried utilities as required for construction whether shown on drawings or not. No extra compensation will be allowed for property damage, injury or loss of time due to obstructions encountered not shown on plans.

L. The Contractor shall be responsible for any damage to curb, gutter, sidewalk, traffic control devices, pavement material and lawns. Any damage resulting directly or indirectly during construction shall be replaced in kind by the Contractor without additional compensation. The reuse of disturbed curb, gutter or sidewalk is prohibited. New sections shall be installed to the nearest undisturbed control joint. Cost for replacement shall be included in the linear foot cost for pipe.

3.2 PIPELINE TRENCH BACKFILL

A. Materials excavated from the trench except topsoil shall be used for trench backfill, provided that, in the opinion of the Engineer, the excavated material is suitable for this purpose. Backfill material shall be free from large lumps, pavement, pieces of concrete and stones.

B. Suitable material, as approved by the Engineer, shall be carefully deposited in the trench by methods which will not damage or disturb the pipeline or structure, and shall be solidly tamped around the pipe or structure. Backfill material shall be placed in 8-inch layers. Compaction shall be accomplished by mechanical tampers. Care shall be taken in the use of mechanical tampers not to injure or move the pipe or to cause the pipe to be supported unevenly. Each layer shall be mechanically tamped for the full trench width unless an alternative method is approved in writing by the Engineer.

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C. Every backfill layer shall be compacted to 95% of maximum density at optimum moisture content as determined by the Modified Proctor Test, ASTM D1557 Method C. Materials containing an excess of moisture shall be permitted to dry until the moisture content is within the specified range. Materials too dry shall be wetted uniformly until the moisture content is in the specified range.

D. No compacting shall be done when the material is too wet to be compacted properly. At such times the work shall be suspended until the backfill materials have dried sufficiently to permit proper compaction or such other precautions shall be taken as may be necessary to obtain proper compaction. The Contractor is responsible for hauling, storing and drying of excavated material to be used in backfill operations within the prices bid.

E. The Engineer may request compaction tests of the backfilled trenches at any time during construction or upon completion of the backfill operations. As a minimum field density testing shall be performed at a rate of 1 test per 100 linear feet of trench, at a depth and location specified by the Engineer or his representative. Such testing shall be arranged by the Contractor and performed by an independent testing agency approved by the Engineer. The Contractor shall pay the testing laboratory for all tests performed inclusive of sample collection, preparation and transportation. The Contractor will be paid, at the unit price bid, for all Proctor tests. For those field density tests which indicate that compaction satisfies specification requirements, the Contractor will be paid for testing at the unit price bid. For those tests which indicate that compaction does not satisfy specification requirements, the Contractor will not be paid. Whenever test results indicate compaction densities less than specified, the Contractor shall, at his own expense, secure the specified compaction using methods approved by the Engineer. The testing agency, so employed by the Contractor, shall submit a copy of all testing reports directly to the Engineer. Each report shall contain the project identification name and number, name of Contractor, name of testing agency, and location of sample tested by station, street and depth, as a minimum.

F. The Contractor shall, at his own expense, maintain all refilled excavations in proper condition. Trench surfaces shall be reshaped when necessary. If the Contractor fails to make repairs within forty eight (48) hours after receipt of written notice from the Owner, the Owner may refill said depression wherever necessary and the cost of so doing will be retained from any monies due or to become due the Contractor under the Contract. The Contractor shall be fully responsible for any injury or damage that may result from lack of maintenance of any refilled excavation at any time prior to final acceptance.

G. All unauthorized excavations made by the Contractor shall be immediately backfilled in accordance with the requirements of the specifications for trench backfill at the Contractor's expense.

H. After completion of backfilling, all material not used shall be disposed of as approved by the Engineer, and all places on the line of the work shall be left clean and in good condition. This cleaning up shall be done by the Contractor without extra compensation. If he fails to do this work within a reasonable time after receipt of notice, it will be performed by the Owner, and the cost will be retained from the monies due the Contractor under the contract.

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I. No backfilling of pipelines will be allowed until measurements of pipe and an inspection has been performed by the Owner's representative, and until the Engineer has authorized the backfill. Any unauthorized backfill of pipelines shall be uncovered by the Contractor at his expense if required by the Engineer.

3.3 EXCAVATION FOR STRUCTURES

A. Excavate for structures, walls, foundations, footings, etc., to the depth and width required for construction and stripping of forms. Structural excavation shall consist of the excavation of all earth, rock boulders existing concrete and masonry foundations and walls, and all other materials encountered regardless of type, which the Contractor may encounter.

B. Excavated materials shall be segregated as they are excavated, with the suitable and unsuitable material and topsoil being piled separately. All suitable material shall be used for backfill. All unsuitable material shall be removed, at the Contractor's expense, and disposed of at an approved off-site location. No excavated material shall be deposited at any time so as to endanger partly finished structures either by direct pressure, or indirectly by overloading banks contiguous to the operation.

C. The Contractor shall be responsible for the condition of all excavations made by him. All slides and cave-ins shall be removed without extra compensation, at whatever time and under whatever circumstances they may occur.

3.4 BACKFILL FOR STRUCTURES

A. Backfill around structures with suitable material from the excavation to the original surface grades or the finished grades shown on the plans or defined by the Engineer. If additional material is needed to fill around the structure, Special Backfill shall be furnished and placed by the Contractor at the price bid in the proposal.

B. No backfill shall be placed against new concrete or masonry structures until properly cured.

C. Backfill shall be placed in eight (8) inch loose layers and compacted by mechanical tampers. Compaction shall conform with the requirements for compaction already set forth in this specification.

D. The Contractor shall exercise caution in backfill and compaction to prevent damage to structures.

3.5 MISCELLANEOUS EXCAVATION AND BACKFILL

A. The Contractor shall do such miscellaneous excavation as may be necessary or directed. Such excavation shall be subject to the same conditions and requirements as specified for trench excavation but will be paid for as "Miscellaneous Excavation and Backfill".

B. Miscellaneous Excavation shall include the digging of test pits in the areas not called out on the project plans, extra width of trench made necessary by change in its location, or excavation for any special structures outside the trench that may not be shown on the

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drawings or described in the specifications, where such excavation is done at the direction of the Engineer.

C. Test pits shall be dug by the Contractor whenever directed or as necessary to determine location, depth or materials of existing utilities. The depth and size shall be such as required by the Engineer. Test pits shall be dug by the Contractor, without being directed to do so, along the lines of the trenches as shown on the drawings in advance of the excavation, or prior to use of mechanical moles, for the purpose of satisfying himself as to the location and elevation of underground obstructions or conditions.

3.6 EXCAVATION BELOW SUBGRADE AND GRAVEL REFILL

A. Materials below the excavation limit for pipelines and structures (below subgrade), which in the judgment of the Engineer should be removed, shall be removed as directed. All spaces created by the removal of unsuitable material below subgrade shall be refilled and compacted with crushed stone or gravel. Payment for Excavation Below Subgrade and Gravel Refill shall be made at the unit price bid.

B. Should the Contractor elect to excavate suitable material below subgrade and install stone for the purpose of securing a dry trench bottom, in lieu of dewatering by mechanical methods, no payment will be made for Excavation Below Subgrade and Gravel Refill.

3.7 DEWATERING

A. All excavations must be kept free of water below the subgrade of the work while work is in progress. This may be accomplished by ordinary pumping methods or by well points, whichever will produce the required results. Upon removal of dewatering equipment, the Contractor shall backfill all holes and restore disturbed areas to their original condition.

B. Dewatering for the structures and pipelines shall commence when groundwater is first encountered and shall be continued until such time as backfill has been completed. No concrete or pipe shall be laid in water nor shall water be allowed to rise over them until the concrete or mortar has set at least eight (8) hours. Groundwater shall not be allowed to rise around the pipe until the trench is backfilled.

C. The Contractor shall dispose of the water from the work in a suitable manner without damage to adjacent property. No water shall be drained into work built or under construction without prior consent of the Engineer. Water shall be disposed of in such a manner as not to be a menace to the Public Health.

D. In the event the Contractor's dewatering operations affect any water supplies within the project area, the Contractor shall take whatever steps that are required to provide uninterrupted water service.

E. The Contractor shall remove any siltation deposits in storm sewer systems, resulting from his dewatering or construction operations. He shall also be responsible for conveyance of dewatering flows and for erosion and sediment control.

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3.8 SHEETING, SHORING AND BRACING

A. The Contractor shall furnish and install all sheeting, shoring and bracing necessary to insure safe working conditions and to prevent damage to public and private property and structures. If, in the opinion of the Engineer, the sheeting, shoring, or bracing is not of proper quality or is not properly placed to insure safe working conditions and to prevent property damage, the Contractor shall remedy such inadequacy at his own expense as may be directed by the Engineer. Sheeting, shoring, and bracing shall be removed as backfilling progresses, except at such locations as the Engineer may direct or approve it to be left in place.

B. The condition of all excavations made by the Contractor shall be the responsibility of the Contractor. No extra compensation will be allowed for property damage, injury or loss of time, due to excavation slides or cave-ins at any time under any circumstances.

C. The Contractor shall cut off any sheeting left in place, at least eighteen (18) inches below finished grade, and shall remove the material cut off without compensation.

D. Where necessary, in quicksand, soft ground, or for the protection of any structure or property, sheeting shall be driven to such depth below the bottom of the trench as may be required to protect all existing and/or proposed work.

E. The cost for furnishing, placing and removal of sheeting, shoring or bracing shall be included in the prices bid.

F. A trench box is an acceptable alternative to sheeting, shoring or bracing providing such boxes conform to safety codes.

3.9 SELECT BACKFILL

A. Should the Contractor encounter unsuitable material during excavation, he shall remove and dispose of such material at a location approved by the Engineer. The cost of such disposal shall be included in the prices bid for pipe and structures.

B. Should sufficient suitable material from excavations on the project not be available for backfill, the Contractor shall furnish Select Backfill upon approval of the Engineer. Backfill shall conform to Delaware DOT Type C.

C. Payment for authorized Select backfill will be made at the price bid for the material placed within the trench width detailed and for the length and depth approved.

3.10 GRAVEL BEDDING

Gravel bedding for installation of under structures shall meet the requirements of #57 stone per Section 1004 of the Delaware Standard Specifications.

END OF SECTION

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SECTION 31 23 16

EXCAVATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Soil densification.
2. Excavating for parking areas.
3. Excavating for landscaping.

1.2 SUBMITTALS

A. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation, as required, to protect excavations and adjacent structures and property. Include structural calculations to support plan.

B. Shop Drawings: Indicate soil densification grid for each size and configuration footing requiring soils densification.

1.3 QUALITY ASSURANCE

A. Licensed Professionals Qualifications: Professional engineer experienced in design of specified Work and licensed in State of Delaware.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Perform Work according to:

1. The State of Delaware Department of Transportation Standards.
2. The Town of Smyrna standards.
3. DNREC Sediment and Stormwater standards.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions for compliance with requirements for maximum moisture content installation tolerances and other conditions affecting performance of the Work.

3.2 PREPARATION

A. Call local utility line information service at 811 not less than three working days before performing Work.

B. Request that underground utilities be located and marked within and immediately surrounding construction areas.

C. Identify required lines, levels, contours, and data.

D. Private locating is required to augment Miss Utility.

E. Existing Utilities:

1. Protect from damage utilities indicated to remain.

F. Protect plant life, lawns, and other features designated to remain as portion of final landscaping.

G. Protect benchmarks, existing structures, fences, sidewalks, paving, curbs, and survey control points from excavating equipment and vehicular traffic.

H. Erect and maintain temporary barriers and security devices, including warning signs, warning lights, and similar measures, for protection of public, Owner, and existing improvements indicated to remain.

3.3 EXCAVATION

A. Underpin adjacent structures which may be damaged by excavation Work.

B. Excavate subsoil to accommodate paving and construction operations.

C. Excavate to working elevation for piling Work.

D. Removal of Deleterious Materials:

1. Remove lumped subsoil, boulders, and rock up to 1/3 cu. yd. (0.25 cu. m), measured by volume.
2. Remove larger material as specified in Section 31 23 23 "Fill".
3. Remove excess and unsuitable material from Site.

E. Correct over-excavated areas as specified in Section 31 23 23 "Fill".

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1. Remove excavated material from Site.
2. Stockpile subsoil in area designated on Site to depth not exceeding 8 feet (2.5 m) and protect from erosion.
3. Stockpile excavated material in area designated on Site as specified in Section 31 05 13 "Soils for Earthwork".

F. Repair or replace items indicated to remain that have been damaged by excavation.

3.4 FIELD QUALITY CONTROL

A. Request visual inspection of bearing surfaces by inspection agency before installing subsequent Work.

3.5 PROTECTION

A. Prevent displacement or loose soil from falling into excavation and maintain soil stability.

B. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.

C. Protect structures, utilities, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that may be created by earth operations.

END OF SECTION

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SECTION 31 23 16.13

TRENCHING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavating trenches for utilities from 5 feet (1.5 mm) outside building to utility service.
2. Compacted fill from top of utility bedding to subgrade elevations.
3. Fill materials.
4. Trench shoring shields or boxes.
5. Temporary steel plates.
6. Geotextiles.
7. Backfilling and compaction.

1.2 DEFINITIONS

A. Excavator: Any entity including, but not limited to, a person, partnership, joint venture, trust, corporation, association, public utility, company, or state or local government body or public agency which performs excavation operations, including the excavation of trenches.

B. Trench: An excavation which is narrow in relation to its length and deeper than it is wide, made more than three feet below grade, with width no greater than 15 feet as measured from the bottom.

C. Trench Shoring: The methods and equipment, including shores and props, used to brace the walls of a trench during excavation work and to prevent the trench walls from collapsing into the trench. Also referred to as trench bracing or trench lining.

D. Utility: Any buried pipe, duct, conduit, or cable.

1.3 SUBMITTALS

A. Excavation Protection Plan: Describe sheeting, trench shoring shields, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations to support plan.

B. Product Data: Submit data for sheeting, shoring, trench shoring shields, and geotextile fabric indicating fabric and construction.

C. Samples:
1. To be taken by testing agency.

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D. Source Quality-Control Reports: For subsoil.

E. Material Test Reports: For each fill material, by a qualified testing agency.

F. Field Quality-Control Reports: For fill material placement and compaction.

1.4 SUSTAINABLE DESIGN SUBMITTALS

A. Product Certificates:

1. For the source and origin for fine- and coarse-aggregate materials.
2. For the source for regional fine- and coarse-aggregate materials and distance from Project Site.
3. For the source and origin for salvaged and reused trench shoring shields and woven and nonwoven geotextile materials.
4. For the source for regional trench shoring shields and woven and nonwoven geotextile materials and distance from Project Site.
5. For recycled trench shoring shields, and geotextile material content for recycled content products.

1.5 QUALITY ASSURANCE

A. Furnish each coarse-aggregate material from single source throughout Work.

1.6 PROTECTION OF UNDERGROUND FACILITIES

A. The Contractor will conduct an investigation to assure that no damage to existing structures, drainage lines, utilities, or conduits will occur.

B. The Contractor is required to use caution when encountering active or abandoned utility structures to avoid possibly disturbing or damaging asbestos-containing materials (ACM), which may be present.

C. While the excavation is open, protect, support, or remove underground installations as necessary.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Perform Work according to:

1. The State of Delaware Department of Transportation standards.
2. The Town of Smyrna standards.
3. DNREC Sediment and Stormwater standards.

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2.2 FILL MATERIALS

A. Subsoil Fill: Type S1, S2 as specified in Section 31 05 13 "Soils for Earthwork".

B. Structural Fill: Type S2, A3 as specified in Section 31 05 13 "Soils for Earthwork" and 31 05 16 "Aggregates for Earthwork".

2.3 TRENCH SHORING SHIELDS OR BOXES

A. Provide professional engineer-certified, high-strength, single-wall or double-wall high-strength steel modular trench shields or box shoring system.

B. Manufacturers:

1. American Shoring Inc.
2. ESC Trench Shoring.
3. PRO-TEC Equipment.
4. Trench Shoring Company.

2.4 TEMPORARY STEEL PLATES

A. Place temporary steel plates over all saw cuts and trenches in roadway areas that will be subjected to traffic during installations.

B. Design the steel plates to size and thickness capable of supporting HS-20 loading, but not less than one inch thick.

C. Submit design criteria and calculations that determine the sizes to be used to Architect/Engineer for approval.

2.5 GEOTEXTILES

A. Filtration Fabric: Provide to line pipe trenches according to Section 31 05 19.13 "Geotextiles for Earthwork," Paragraph 2.3 - Nonwoven Geotextile Materials.

B. Erosion Control: Provide erosion control and subsurface drainage geotextile as required for trench Work according to Section 31 05 19.13 "Geotextiles for Earthwork," Paragraph 2.4 - Woven Geotextiles for Erosion Control.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions for compliance with requirements for maximum moisture content, installation tolerances and other conditions affecting performance of the Work.

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3.2 LINES AND GRADES

A. Lay pipes and conduit to lines and grades as indicated.

B. Use laser-beam instrument with qualified operator to establish lines and grades.

C. Maintain grade alignment of pipe and conduit using string line parallel with grade line and vertically above centerline of pipe or conduit.

1. Establish string line on level batter boards at intervals of not more than 25 feet.

3.3 PREPARATION

A. Call local utility line information service at 811 not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.
2. Provide adequate means of protecting utilities to remain in place during trench excavation operations.
3. Private utility locating needed to augment Miss Utility.
4. Should uncharted or incorrectly charted piping or other utilities be encountered during trench excavation, consult Architect/Engineer immediately for directions. Keep respective services and facilities in operation. Repair damaged utilities to the satisfaction of Owner.

B. Establish temporary traffic control and detours when trenching is performed in public right-of-way. Relocate controls and reroute traffic as required during progress of Work.

3.4 TRENCHING

A. Excavate subsoil required for utilities to utility service.

B. Remove lumped subsoil, boulders, and rock more than 1/6 cu. yd. measured by volume.

C. Perform excavation within 24 inches of existing utility service according to utility's requirements.

D. Do not advance open trench more than 200 feet ahead of installed pipe or conduit.

E. Cut trenches to width as indicated. Remove water or materials that interfere with Work according to OSHA 29 CFR 1926.650.

F. Excavate bottom of trenches maximum 2 feet wider than outside diameter of pipe or conduit.

G. Provide uniform and continuous bearing and support for bedding material and utilities.

H. Do not interfere with 45-degree bearing splay of trench or foundations.

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I. Slope side walls of excavation starting 2 feet above top of pipe or conduit. When side walls cannot be sloped, provide sheeting and trench shoring shields to protect excavation.

J. When subsurface materials at bottom of trench are loose or soft, notify Architect/Engineer and request instructions.

K. Correct over-excavated areas with compacted backfill as specified for authorized excavation or replace with fill concrete as directed by Architect/Engineer.

L. Remove from Site excess subsoil not intended for reuse.

M. Remove subsoil from Site.

N. Stockpile subsoil in area designated on Site to depth not exceeding 8 feet and protect from erosion.

O. Stockpile excavated material in area designated on Site according to Section 31 05 13 "Soils for Earthwork." And 31 05 16 "Aggregates for Earthwork**."**

3.5 SHEETING, SHORING, AND TRENCH SHORING SHIELDS

A. Utilize sheeting, shoring, and trench shoring shields and brace excavations to prevent danger to persons, structures, and adjacent properties and to prevent caving, erosion, and loss of surrounding subsoil.

B. Support trenches more than 5 feet deep excavated through unstable, loose, or soft material. Provide sheeting, shoring, bracing, trench shoring shields, or other protection to maintain stability of excavation.

C. When sheeting is used, drive it ahead of the excavation operations to avoid the loss of material from behind the sheeting. Fill voids that occur outside of the sheeting with gravel borrow, thoroughly compacted.

D. Assemble and place trench shoring shields according to manufacturer's written instructions.

E. Design sheeting and shoring to be left in place as part of the completed Work, cut off minimum 18 inches below finished grade.

F. Design sheeting and shoring to be removed at completion of excavation Work.

G. Repair damage to new and existing Work from settlement, water pressure, earth pressure, or other causes resulting from inadequate sheeting, shoring, trench shoring shields, or bracing.

3.6 BACKFILLING

A. Backfill trenches to contours and elevations with unfrozen fill materials.

B. Place fill material in continuous layers and compact.

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C. Place material in continuous layers as follows:

1. Subsoil Fill: Maximum 8 inches compacted depth.
2. Structural Fill: Maximum 8 inches compacted depth.

D. Employ placement method that does not disturb or damage foundation perimeter drainage, utilities in trench.

E. Protect open trench to prevent danger to the public.

3.7 FIELD QUALITY CONTROL

A. Perform laboratory material tests according to ASTM D1557.

B. Perform in place compaction tests according to the following:

1. Density Tests: ASTM D1556.
2. Moisture Tests: ASTM D6938.

C. When tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.

D. Frequency of Tests: 1 per 100 linear feet of trench.

3.8 PROTECTION OF FINISHED WORK

A. Reshape and recompact fills subjected to vehicular traffic during construction.

END OF SECTION

NOT FOR BIDDING PURPOSES

SECTION 31 23 23

FILL

NOT FOR BIDDING PURPOSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fill.
2. Geotextiles.

1.2 SUBMITTALS

A. Product Data: For fill materials and geotextiles.

B. Samples:

1. To be taken by the testing agency.

C. Source Quality-Control Reports: For subsoil.

1.3 QUALITY ASSURANCE

A. Manufacturers Qualifications: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.

B. Installers Qualifications: Company specializing in performing Work of this Section with minimum three years' documented experience and approved by manufacturer.

C. Licensed Professionals Qualifications: Professional engineer experienced in design of specified Work and licensed in State of Delaware.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Perform Work according to:

1. The State of Delaware Department of Transportation Standards.
2. The Town of Smyrna standards.
3. DNREC Sediment & Stormwater standards.

2.2 FILL

A. Subsoil Fill: Type S2 as specified in Section 31 05 13 "Soils for Earthwork".

B. Structural Fill: Type S2, as specified in Section 31 05 13 "Soils for Earthwork", 31 05 16 "Aggregates for Earthwork".

C. Concrete:
1. Structural concrete.

2.3 GEOTEXTILES

A. Geotextile Fabric: Provide erosion control, subsurface drainage, and soil reinforcement geotextile according to Section 31 05 19.13 "Geotextiles for Earthwork."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions for compliance with requirements for maximum moisture content, installation tolerances and other conditions affecting performance of the Work.

B. Verify inspection of subdrainage, dampproofing, and waterproofing installations.

C. Verify that underground tanks are anchored to their own foundations.

D. Verify structural integrity of unsupported walls.

3.2 PREPARATION

A. Call local utility line information service at 811 not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

B. Private utility locating required to augment Miss Utility.

C. Identify required lines, levels, contours, and datum.

D. Protect utilities indicated to remain free from damage.

E. Compact subgrade to specified density requirements for subsequent backfill materials.

F. Soft Subgrade:

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1. Cut out soft areas of subgrade not capable of compaction in place.
2. Backfill with structural fill and compact to density equal to or greater than specified requirements for subsequent fill material.

G. Scarify subgrade surface to depth of 3 inches.

H. Protect benchmarks, survey control point, existing structures, fences, sidewalks, paving, and curbs during construction.

3.3 BACKFILLING

A. Backfill areas to contours and elevations.

B. Systematically backfill to allow maximum time for natural settlement.

C. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces, and do not backfill with frozen materials.

D. Geotextile: Place geotextile fabric prior to placing subsequent fill materials as specified in Section 31 05 19.13 "Geotextiles for Earthwork."

E. Place fill material in continuous layers and compact according to Fill Schedule included in Evaluations.

F. Maximum Compacted Depths:

1. Place material in continuous layers to following depths:

a. Subsoil Fill: Maximum 8 inches compacted depth.
b. Structural Fill: Maximum 8 inches compacted depth.

G. Use placement method that does not disturb or damage foundation perimeter drainage, utilities in trench.

H. Maintain optimum moisture content of fill materials to attain required compaction density.

I. Structures:

1. Backfill against supported foundation walls.
2. Backfill simultaneously on each side of unsupported foundation walls until supports are in place.
3. Slope grade away from building minimum 5 percent slope for minimum distance of 10 feet.

J. Make gradual grade changes and blend slope into level areas.

K. Remove surplus backfill materials from Site.

L. Leave fill material stockpile areas free of excess fill materials.

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M. Install Work according to Town of Smyrna standards.

3.4 TOLERANCES

A. Top Surface of Backfilling within Building Areas: Plus or minus 1 inch from required elevations.

B. Top Surface of Backfilling under Paved Areas: Plus or minus 1 inch from required elevations.

C. Top Surface of General Backfilling: Plus or minus 1 inch from required elevations.

3.5 FIELD QUALITY CONTROL

A. Inspections: Request visual inspection of bearing surfaces by inspection agency before installing subsequent Work.

B. Testing:

1. Laboratory Material Testing: Comply with ASTM D1557.
2. In-Place Compaction Testing:

    a. Density Tests: Comply with ASTM D1556/D1556M, D2167, orD6938.
    b. Moisture Tests: Comply with ASTM D6031/D6031M.

3. If tests indicate that Work does not meet specified requirements, remove Work, replace, compact, and retest.
4. Testing Frequency: As determined by Engineer.
5. Proof-roll compacted fill surfaces under paving.

3.6 PROTECTION

A. Reshape and recompact fills subjected to vehicular traffic during construction.

END OF SECTION

NOT FOR BIDDING PURPOSES

SECTION 31 25 00

EROSION & SEDIMENT CONTROL

PART 1 - GENERAL

1.1 DESCRIPTION

Provide necessary equipment, labor and supplies for erosion and sediment control throughout project. Work consists of grading of site, providing silt fence, inlet protection, and straw bale dikes and other necessary measures required for effective control. Sediment and erosion control work shall comply with the requirements of the State of Delaware Erosion and Sediment Control Handbook, 2023 Addition, and the Delaware Sediment and Stormwater Regulations, issued February 2019. The receipt of a proposal by a bona fide bidder shall be interpreted to mean the Contractor has familiarized himself with these Regulations and Rules of Procedure and is fully cognizant of exactly what is required.

1.2 SUBMITTALS

A. Erosion and Sediment Control Schedule.

At pre-construction conference or prior to start of actual construction, submit for acceptance, schedules for accomplishment of temporary and permanent erosion control work. Submit schedule for each of the following procedures: Grading, construction and paving. No work shall be started until erosion control schedules and methods of operation have been approved.

1.3 EXECUTION

A. Throughout the duration of the project, control erosion and minimize siltation to rivers, streams and impoundments. Control shall include, but is not limited to the use of berms, dikes, dams, sediment basins, sediment traps, filters, fiber mats, netting, gravel or crushed stone, mulch, grasses, slope drains, and other methods. Erosion and sediment control measures as described herein and on the drawings shall be applied to erodible materials exposed by any project activity.

B. Coordinate erosion and sediment control measures with the construction of the permanent drainage facilities which shall be constructed prior to the grading operation to assure economical, effective and continuous erosion and siltation control.

C. Dress, prepare, and seed slopes immediately following the completion of each portion of work and immediately following suspension of grading operations.

D. Fill slopes shall be dressed, prepared and seeded as the embankment proceeds to the extent needed to stop erosion and sedimentation.

E. The Contractor shall incorporate permanent erosion control features into the project at the earliest practicable time. Temporary erosion control measures shall be used to correct conditions that develop during construction that were not foreseen during the design stage, that are needed prior to installation of permanent erosion control features, or that

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are needed temporarily to control erosion that develops during normal construction practices that are not associated with permanent control features of the project.

END OF SECTION

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SECTION 31 31 16

TERMITE CONTROL

PART 1 - GENERAL

1.01 SUMMARY

A. Provide soil treatment for termite control.

1.02 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Warranty: Submit manufacturer's standard warranty. Include labor and materials to repair or replace defective materials.

1. Warranty Period: 5 years.

1.03 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Soil Treatment Materials: Soil treatment materials shall bear Federal registration number of U.S. Environmental Protection Agency and acceptable to authorities having jurisdiction. If acceptable, products may include chloropyrifos, permathrin, cypermethrine, fenvalerate, isofenphose.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Treat soil in strict compliance with National Pest Control Association standards and with manufacturer's printed instructions and recommendations.

B. Treat areas under floor slabs prior to placement of concrete if possible to avoid drilling. Treat areas outside foundation walls after excavation, filling and grading are complete. Do not apply treatment to frozen or excessively wet soils.

C. Post signs and other warnings indicating that soil poisoning has been applied. Protect persons and property from injury or damage from soil treatment work.

END OF SECTION

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SECTION 31 32 00

SOIL STABILIZATION

PART 1 - GENERAL

1.1 Includes topsoil, fertilizers and lime for unpaved disturbed areas as shown on the Drawing.

1.2 SUBGRADE

A. To be neutralized with lime if highly acid or composed of heavy clay.

1.3 SUBMITTALS

A. Laboratory test results of topsoil for PH, soluble salts and application requirements for lime and fertilizer.

1.4 Related work specified elsewhere: Turf and Grass 32 92 00.

PART 2 - PRODUCTS

2.1 TOPSOIL

A. Sandy loam, silt loam, or other soil approved by the Owner.

B. Shall not contain subsoil, slag, cinders, stones, lumps of soil, sticks, roots, trash or other extraneous materials larger than 1" in diameter or length.

C. Must be free of plants or plant parts of bermuda grass, quackgrass, Johnson grass, nutsedge, poison ivy, Canadian thistle, or others as specified.

D. A pH of 5.0 to 7.0 is required.

E. Soluble salts shall not be higher than 500 parts per million.

2.2 FERTILIZERS

A. Uniform in composition, free flowing and suitable for application with approved equipment.

B. Delivered to the site fully labeled according to applicable State Fertilizer Laws and shall bear the name, trade name or trade-mark and warranty of the producer.

C. Fertilizer application rates shall be determined by soil tests per the approved sediment & erosion control plan.

D. Fertilizer shall be distributed evenly over the area to be seeded.

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2.3 LIME

A. Shall be ground limestone (hydrated or burnt lime may be substituted) which contains at least 50% total oxides (calcium oxide plus magnesium oxide).

B. Ground limestone shall be ground to such fineness that at least 50% will pass through a 100-mesh sieve and 98 to 100% will pass through a 20-mesh sieve.

C. Application rates of liming materials shall be per the approved sediment & erosion control plan.

D. Lime shall be distributed uniformly over the entire areas to be seeded.

PART 3 - EXECUTION

3.1 SUBSOIL

A. Test for PH. If highly acid apply ground limestone at the rate of 100 pounds per 1,000 sq. ft.

B. Immediately prior to placing topsoil, loosen subsoil by disking or scarifying to a depth of at least two inches.

3.2 TOPSOIL

A. Topsoil shall be uniformly distributed on the designated areas and it shall be a minimum depth of 4 inches after firming.

B. Spreading shall be performed in such a manner that seeding can proceed with a minimum of additional soil preparation and tillage.

C. Any irregularities in the surface resulting from topsoiling or other operations shall be corrected in order to prevent the formation of depressions or water pockets.

D. Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet, or in a condition that may otherwise be detrimental to proper grading or proposed seeding.

E. After the topsoiling has been spread and the final grades approved, it shall be cleared of all grade stakes, surface trash and other objects that would hinder maintenance of seeded and planted areas.

F. Paved areas over which hauling operations are conducted shall be kept clean, and any soil which may be brought upon the surfacing shall be promptly removed.

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G. The wheels of all vehicles shall be kept clean to avoid tracking soil on the surfacing of roads, walks or other paved areas.

H. Lime and fertilizer shall be uniformly mixed into the top 4 inches of soil by disking, harrowing or other approved methods.

I. Any undulations or irregularities in the surface resulting from fertilizing, liming, tilling or other causes shall be leveled prior to seeding.

J. Flooded, washed out or areas otherwise damaged shall be reconstructed and all grades re-established by the landscape contractor in accordance with the drawings and/or other applicable specifications.

END OF SECTION

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SECTION 31 50 00

EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.01 SUMMARY

A. Provide shoring and bracing for sidewalls in deep excavations with steel sheet, soldier piles or timber lagging to protect existing buildings, utilities, roadways, and improvements.

1.02 SUBMITTALS

A. Shop Drawings: Layout of shoring and bracing and other data, acceptable to local authorities having jurisdiction, prepared by a qualified professional engineer.

1.03 QUALITY ASSURANCE

A. Survey of Adjacent Structures and Levels: Registered land surveyor prior to excavation.

B. Engineer: A professional engineer licensed in the jurisdiction of the project.

C. System Design: Prevent cave-ins, loss of ground, or damage to people and property. Maintain shoring and bracing during construction activities and remove shoring and bracing if practical when construction and filling is complete.

D. Comply with codes and ordinances of governing authorities having jurisdiction. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Sheet steel: Heavy-gauge steel sheet suitable for service.

B. Soldier piles: Steel H-beams in serviceable condition.

C. Timber lagging: Heavy timber pressure treated with wood preservative.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in proper relation with adjacent construction to permit forming and finishing of concrete surfaces. Coordinate with work of other sections.

B. Locate shoring and bracing to avoid permanent construction. Anchor and brace to prevent collapse.

END OF SECTION

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SECTION 32 11 26

BITUMINOUS STABILIZED BASE COURSES

PART 1 – GENERAL

1.01 SUMMARY

A. Provide hot-mixed asphalt paving over prepared subbase and roadway markings.

1.02 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Test Reports: Submit for approval test reports.

1.03 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

B. Construction Tolerances:

1. Surface Course Thickness: Within 1/4 inch.
2. Base Course Surface Smoothness: Within 1/4 inch.
3. Surface Course Surface Smoothness: Within 3/16 inch. No ponding acceptable.
4. Crowned Surfaces: Within 1/4 inch from template.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Asphalt-Aggregate Mixture: Plant-mixed, hot-laid asphalt-aggregate mixture, ASTM D 3515, complying with local DOT and DPW regulations.

B. Prime Coat: Cut-back asphalt, ASTM D 2027.

C. Tack Coat: Emulsified asphalt, ASTM D 977.

D. Herbicide Treatment: Commercial chemical for weed control registered by Environmental Protection Agency and acceptable to authorities having jurisdiction.

E. Lane and Parking Area Marking Paint, Color as indicated on plan: Alkyd-resin type, ready-mixed, AASHTO M 248, Type I.

F. Lane and Parking Area Marking Paint, Color as indicated on plan: Alkyd-resin type, ready-mixed, AASHTO M 248, Type I.

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PART 3 - EXECUTION

3.01 INSTALLATION

A. Asphalt/Aggregate Mixture: Comply with local DOT or DPW Standard Specifications for Highways and Bridges. Class as required by loading and use.

B. Remove loose material from compacted subbase. Proof roll and check for areas requiring additional compaction. Report unsatisfactory conditions in writing. Beginning of work means acceptance of subbase.

C. Apply prime coat to prepared subbase. Apply tack coat to previous laid work and adjacent in-place concrete surfaces.

D. Place asphalt concrete at minimum temperature of 225 degrees F in strips not less than 10' wide overlapping previous strips. Complete entire base course before beginning surface course.

E. Construct curbs to dimensions indicated or if not indicated to standard shapes. Provide tack coat between curb and pavement.

F. Begin rolling when pavement can withstand weight of roller. Roll while still hot to obtain maximum density and to eliminate roller marks.

G. Provide 4" lane and striping paint in uniform, straight lines. Provide wheelstops where indicated and securely dowel into pavement. Protect work from traffic and damage.

H. Test in-place asphalt work for thickness and smoothness. Remove and replace defective work and patch to eliminate evidence of patching.

END OF SECTION

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SECTION 32 11 36

CONCRETE BASE COURSES

PART 1 - GENERAL

1.01 SUMMARY

A. Provide cast-in-place concrete paving over prepared subbase.

1.02 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Design Mixes: Submit for approval design mixes, including adjustments for variations in project conditions.

C. Test Reports: Submit for approval test reports.

1.03 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

B. Construction Tolerance: 1/8" in 10' for grade and alignment of top of forms; 1/4" in 10' for vertical face on longitudinal axis.

C. Testing: Independent testing laboratory.

D. Mock-Ups: Provide mock-up as required to demonstrate quality of workmanship.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Concrete: ASTM C 150, Type I, Portland cement; ASTM C 33, normal weight aggregates; potable water.

1. Design Mix: ASTM C 94, 3000 psi, 28-day minimum compressive strength.
2. Slump Limits: 2" - 5".
3. Air Content: 5 to 8 percent.
4. Finish: Broom finish, perpendicular to direction of travel.

B. Wire Mesh Reinforcement: Welded plain steel wire fabric, ASTM A 185.

C. Reinforcing Bars: Deformed steel bars, ASTM A 615, Grade 60.

D. Fabricated Bar Mats: Steel bar or rod mats, ASTM A 184, using ASTM A 615, Grade 60 steel bars.

E. Joint Dowel Bars: Plain steel bars, ASTM A 615, Grade 60.

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F. Hook Bolts: ASTM A 307, Grade A threaded bolts.

G. Liquid-Membrane Forming and Sealing Curing Compound: ASTM C 309, Type I, Class A.

H. Bonding Compound: Polyvinyl acetate or acrylic base.

I. Epoxy Adhesive: ASTM C 881.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Proof roll subbase and check for unstable areas. Report unsatisfactory conditions in writing. Beginning paving work means acceptance of subbase.

B. Comply with concrete section for concrete mix, testing placement, joints, tolerances, curing, repairs and protection.

C. Dispose of over-mixed concrete off-site in a legal manner.

D. Protect concrete paving until weight of a person will not leave any impression. Remove and replace concrete paving which shows impressions or other defects. Skim coating defects is not acceptable.

END OF SECTION

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SECTION 32 12 16

ASPHALT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cold milling of existing asphalt pavement.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving.
4. Hot-mix asphalt overlay.

B. Related Requirements:

1. Section 02 41 16 "Structural Demolition" for demolition and removal of existing asphalt pavement.
2. Section 31 00 00 "Earthwork" for subgrade preparation, fill material, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.
3. Section 32 13 73 "Concrete Paving Joint Sealants" for joint sealants and fillers at pavement terminations.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:

a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
b. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

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1. Include technical data and tested physical and performance properties.
2. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
3. Job-Mix Designs: For each job mix proposed for the Work.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located.

B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of Standard Specifications for Road and Bridge Construction Manual, June 2022 including all addenda of Delaware Department of Transportation for asphalt paving work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:

1. See 2022 DelDOT Standard Specifications, Section 401 for environmental limitations.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. Coarse Aggregate: See Division 302 and 1004 of 2022 DelDOT Specifications.

C. Fine Aggregate: See Division 302 and 1004 of 2022 DelDOT Specifications

2.2 ASPHALT MATERIALS

A. Asphalt Binder: See Division 400 and 1014 of 2022 DelDOT Specifications

B. Asphalt Cement: See Division 400 and 1012 of 2022 DelDOT Specifications

C. Cutback Prime Coat: See Division 400 and 1011 of 2022 DelDOT Specifications

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D. Emulsified Asphalt Prime Coat: See Division 400 and 1011 of 2022 DelDOT Specifications

E. Tack Coat: See Division 400 and 1011 of 2022 DelDOT Specifications

F. Fog Seal: See Division 400 and 1000 of 2022 DelDOT Specifications

G. Water: Potable.

H. Undersealing Asphalt: See Division 400 and 1000 of 2022 DOT Specifications

2.3 AUXILIARY MATERIALS

A. Recycled Materials for Hot-Mix Asphalt Mixes: See Division 400 and 1014 of 2022 DelDOT Specifications

B. Herbicide: Commercial chemical for weed control, registered by the EPA, and not classified as "restricted use" for locations and conditions of application. Provide in granular, liquid, or wettable powder form.

C. Sand: See Division 400 and 1003 of 2022 DelDOT Specifications

D. Paving Geotextile: AASHTO M 288 paving fabric; nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications.

E. Joint Sealant: See Division 400 and 1042 of 2022 DelDOT Specifications

2.4 MIXES

A. Recycled Content of Hot-Mix Asphalt: See Division 400 and 1012 of 2022 DelDOT Specifications

B. Hot-Mix Asphalt: See Division 400 and 1014 of 2022 DelDOT Specifications
1. Base Course: PG 64-22.
2. Surface Course: PG 64-22.

C. Emulsified-Asphalt Slurry: See Division 400 and 1016 of 2022 DelDOT Specifications

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proof-roll exposed subgrade as outlined in Section 31 00 00 “Earthwork”.

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C. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades. Proof-roll to be completed in the presence of Architect/Engineer and/or Geotechnical Engineer.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons. Super proof roll by overlapping passes by a half a vehicle width.
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

D. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 COLD MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.

1. Mill all existing hot mix to the base course.
2. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
3. Control rate of milling to prevent tearing of existing asphalt course.
4. Repair or replace curbs, manholes, and other construction damaged during cold milling.
5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
6. Handle milled asphalt material according to approved waste management plan required in Section 01 74 19 "Construction Waste Management and Disposal."
7. Keep milled pavement surface free of loose material and dust.
8. Do not allow milled materials to accumulate on-site.

3.3 PATCHING

A. Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.

1. Pump hot undersealing asphalt under rocking slab until slab is stabilized or, if necessary, crack slab into pieces and roll to reseat pieces firmly.
2. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.

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C. Tack Coat: Before placing patch material, apply tack coat uniformly to vertical asphalt surfaces abutting the patch. Apply in accordance with Division 400 and 1011 of 2022 DelDOT Specifications.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Placing Patch Material: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

3.4 REPAIRS

A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch in existing pavements.

1. Install leveling wedges in compacted lifts not exceeding 2 inches thick.

3.5 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

1. Mix herbicide with prime coat if formulated by manufacturer for that purpose.

C. Cutback Prime Coat: Apply in accordance with Division 400 and 1011 of 2022 DelDOT Specifications.

D. Emulsified Asphalt Prime Coat: Apply in accordance with Division 400 and 1011 of 2022 DelDOT Specifications.

E. Tack Coat: Apply in accordance with Division 400 and 1011 of 2022 DelDOT Specifications.

3.6 PLACING HOT-MIX ASPHALT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
2. Place hot-mix asphalt surface course in single lift.

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3. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
4. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
5. Apply in accordance with Division 400 and 1014 of 2022 DelDOT Specifications

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1-1/2 inches from strip to strip to ensure proper compaction of mix along longitudinal joints.
2. Complete a section of asphalt base course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.7 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
3. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.8 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to temperature specified in Division 400 and 1014 of 2022 DelDOT Specifications.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

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C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the density specified in Division 400 and 1014 of 2022 DelDOT Specifications:

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.9 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 1/2 inch.
2. Surface Course: Plus 1/4 inch, no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:

1. Base Course: 1/4 inch.
2. Surface Course: 1/8 inch.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

D. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

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3.11 WASTE HANDLING

A. General: Handle asphalt-paving waste according to approved waste management plan required in Section 01 74 19 "Construction Waste Management and Disposal."

END OF SECTION

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SECTION 32 13 13

CONCRETE PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Parking lots
2. Curbs and gutters
3. Walks
4. Pads

B. Related Sections:

1. Section 03 30 00 "Cast-in-Place Concrete" for general building applications of concrete.
2. Section 32 13 73 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement, Class A, alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Other Action Submittals:

1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

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1.5 QUALITY ASSURANCE

A. Detectable Warning Installer Qualifications: An employer of workers trained and approved by manufacturer of stamped concrete paving systems.

B. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

C. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

D. Concrete Testing Service: Owner to perform material evaluation tests and to design concrete mixtures.

E. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.

F. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to concrete paving, including but not limited to, the following:

a. Concrete mixture design.
b. Quality control of concrete materials and concrete paving construction practices.

2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:

a. Contractor's superintendent.
b. Concrete paving subcontractor.

1.6 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

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PART 2 - PRODUCTS

2.1 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.2 STEEL REINFORCEMENT

A. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, fabricated from as-drawn steel wire into flat sheets.

B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.

C. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" of greater compressive strength than concrete specified, and as follows:

1. For concrete surfaces exposed to view where legs off wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI 2 stainless-steel bar supports.

2.3 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source throughout Project:

1. Portland Cement, Class A: See Divisions 500 and 1022 of DelDOT Specifications.

B. Normal-Weight Aggregates: See Divisions 500, 1003, and 1004 of DelDOT Specifications.

C. Water: Potable and complying with ASTM C 94/C 94M and potable.

D. Air-Entraining Admixture: See Divisions 500 and 1022 of DelDOT Specifications.

E. Chemical Admixtures: See Divisions 500 and 1022 of DelDOT Specifications.

2.4 FIBER REINFORCEMENT

A. Synthetic Fiber: See Divisions 500 and 1022 of DelDOT Specifications.

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2.5 CURING MATERIALS

A. See Divisions 500 and 1022 of DelDOT Specifications for the various curing materials available for use.

2.6 RELATED MATERIALS

A. Joint Fillers: See Divisions 500 and 1042 of DelDOT Specifications.

B. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

2.7 DETECTABLE WARNING MATERIALS

A. Detectable Warning Stamp: See DelDOT Standard Construction Details for warning domes.

2.8 PAVEMENT MARKINGS

A. See Section 32 17 23 “Pavement Markings”.

2.9 CONCRETE MIXTURES

A. See DelDOT Divisions 500 and 1022 for concrete mixes for sidewalk, dumpster pad and curb.

B. Proportion mixtures to provide normal-weight concrete with the following properties:

1. See DelDOT Divisions 500 and 1022 for compressive strength and slump requirements.

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. See DelDOT Divisions 500 and 1022.

D. Limit water-soluble, chloride-ion content in hardened concrete as permitted in DelDOT Divisions 500 and 1022.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

1. See DelDOT Divisions 500 and 1022.

F. Cementitious Materials: See DelDOT Divisions 500 and 1022.

G. Synthetic Fiber: See DelDOT Divisions 500 and 1022.

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2.10 CONCRETE MIXING

A. Ready-Mixed Concrete: See DelDOT Divisions 500 and 1022 for mixing, delivery and placement requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades, subbase and base surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll exposed subgrade as outlined in Section 31 00 00 “Earthwork”.

C. Proof-roll prepared subgrade surface below dumpster pad, curbing and internal sidewalks to identify soft pockets and areas of excess yielding. Proof-roll to be completed in the presence of Architect/Engineer and/or Geotechnical Engineer.

1. Completely super proof-roll subgrade in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph. The passes shall overlap a half a truck width for each pass.
2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. Correct base with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Section 31 00 00 "Earthwork."

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

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B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

E. Zinc-Coated Reinforcement: Use galvanized-steel wire ties to fasten zinc-coated reinforcement. Repair cut and damaged zinc coatings with zinc repair material.

F. Epoxy-Coated Reinforcement: Use epoxy-coated steel wire ties to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963/D 3963M.

G. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap of adjacent mats.

3.5 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
2. Provide tie bars at sides of paving strips where indicated.
3. Butt Joints: Use bonding agent at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 15’ for sidewalks and 10’ for curbs unless otherwise indicated.

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2. Extend joint fillers full width and depth of joint.
3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows, to match jointing of existing adjacent concrete paving:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.

a. Tolerance: Ensure that grooved joints are within 3 inches either way from centers of dowels.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

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G. Consolidate concrete according to ACI 301 (ACI 301M) by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating joint devices.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.

K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.

1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

L. Cold-Weather Placement: See DelDOT Specifications for cold weather placement.

M. Hot-Weather Placement: See DelDOT Specifications for hot weather placement.

N. Sidewalks: See DelDOT Specifications for placing concrete for sidewalks.

3.7 FLOAT FINISHING

A. General: See DelDOT Specifications for float finishes.

3.8 DETECTABLE WARNINGS

A. See DelDOT Standard Construction Details for detectable warning domes.

3.9 CONCRETE PROTECTION AND CURING

A. See DelDOT Specification Divisions 500 and 1000 for concrete protection and curing.

3.10 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:

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1. Elevation: 3/4 inch.
2. Thickness: Plus 3/8 inch, minus 1/4 inch.
3. Surface: Gap below 10-foot long, unleveled straightedge not to exceed 1/8 inch.
4. Joint Spacing: 3 inches.
5. Contraction Joint Depth: Plus 1/4 inch, no minus.
6. Joint Width: Plus 1/8 inch, no minus.

3.11 PAVEMENT MARKING

A. See 32 17 23 “Pavement Markings”.

3.12 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each concrete mixture placed each day.

    a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.

    a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project

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identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

G. Concrete paving will be considered defective if it does not pass tests and inspections.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

I. Prepare test and inspection reports.

3.13 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with Portland cement Class A concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION

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SECTION 32 13 16

DECORATIVE CONCRETE PAVING

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, specifications and general provisions of Contract, including General and Supplementary Conditions and other Division-I Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes colored and scored concrete paving.

B. Related Requirements:
1. Section 32 13 13 “Concrete Paving” for additional concrete paving information

1.3 DEFINITIONS

A. Decorative Concrete: A cast-in-place concrete slab, integrally colored. The work is performed on the job site by trained and experienced workers.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color.
1. Color charts for all concrete coloring products
2. Color chart for joint sealant.

C. Samples for Final Selection:
1. For each color specified, provide three 12” x 12” or larger samples of colored concrete with specified liquid color (three colors). Provide one additional sample if initial samples are not approved.

D. Other Action Submittals:

1. Design Mixtures: For each decorative concrete paving mixture. Include alternate design mixtures when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

E. Qualification Data:
1. Concrete Contractor: Submit a list of at least five successfully completed projects of similar scale and complexity. Include project name, project address and owner contact

information. Submit evidence that the project supervisor has at least five years' experience with colored and textured concrete.

1.5 INFORMATIONAL SUBMITTALS

A. Material Certificates: For the following, from manufacturer:

1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Admixtures.
4. Curing compounds.
5. Joint fillers.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: All Decorative Concrete work shall be installed by an experienced contractor. The contractor shall provide a qualified foreman or supervisor who has a minimum of five years' experience with colored and textured concrete, and who has successfully completed at least five textured concrete installations of high quality and similar in scope to that specified herein, and located within a 100 mile radius of the proposed project. An employer of workers trained and approved by manufacturer of decorative concrete paving systems.

B. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products with integral color and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

C. Testing Agency Qualifications: comply with requirements of Section 03 30 00 "Cast In Place Concrete".

D. Source Limitations: Obtain all products for coloring and texturing concrete, and the redi-mix concrete from a single source.

E. Concrete Testing Service: Engage a qualified testing agency to perform material evaluation tests and to design concrete mixtures.

F. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockups of full-thickness sections of decorative concrete paving to demonstrate typical joints; integral color, curing; and standard of workmanship.
2. Build mockups of decorative concrete paving in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than 48" by 60".
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

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4. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

G. Preinstallation Conference: Conduct conference at project site.

1. Review methods and procedures related to decorative concrete paving, including but not limited to, the following:

a. Concrete mixture design.
b. Quality control of concrete materials and decorative concrete paving construction practices.

1.7 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:

1. When air temperature has fallen to or is expected to fall below 40 deg F (4.4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.
2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

C. Hot-Weather Concrete Placement: Comply with ACI 301 (ACI 301M) and Section 32 13 13 “Concrete Paving”

PART 2 - PRODUCTS

2.1 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

1. Use flexible or uniformly curved forms for curves of a radius of 100 feet or less. Do not use notched and bent forms.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

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2.2 STEEL REINFORCEMENT

A. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, welded wire mesh, roll type, size as indicated.

B. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420) plain-steel bars. Cut bars true to length with ends square and free of burrs.

C. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2.3 CONCRETE MATERIALS

A. See Section 32 13 13 “Concrete Paving” Air-Entraining Admixture: ASTM C 260 shall be used to achieve an entrained air content for the particular mix used in accordance with the published recommendations of the Portland Cement Association and the ACI.

B. Chemical Admixtures: no admixtures using calcium chloride shall be permitted.
1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.

C. Curing Compound for Colored Concrete: Curing compound shall comply with ASTM C309 and be approved by color additive manufacturer for use with colored concrete.

D. Do not use fly ash or slag in colored concrete.

2.4 CONCRETE COLORING MATERIALS

A. Iron Oxide Pigment: ASTM C 979-82, predispersed iron oxide pigments containing high pigment solids in aqueous base liquid, color stable with uniform and consistent color, permanent, inert, stable to atmospheric conditions, sunfast, weather resistant, alkali resistant, water insoluble, lime proof and nonbleeding.

B. Manufacturer: Subject to the requirements, provide products from the following manufacturers:
1. Davis Colors
2. Solomon Colors
3. SIKA USA
4. Color: to be selected from manufacturer’s standard colors.

2.5 RELATED MATERIALS

A. Joint Fillers:

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1. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.
2. Material: ASTM D 1752, self-expanding cork in preformed strips.

B. Polyethylene Film: ASTM D 4397, 1 mil (0.025 mm) thick, clear.

C. Colored Joint Sealant: To match colored concrete.

2.6 CONCRETE MIXTURES

A. See Section 32 13 13 “Concrete Paving” Chemical Admixtures: Use admixtures designed for use with concrete pigments, use according to manufacturer's written instructions.

1. Use water-reducing admixture or water-reducing and retarding admixture in concrete as required for placement and workability.
2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

B. Cementitious Materials: Do not substitute slag or fly ash for portland cement.

C. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

2.7 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.

1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
2. For concrete batches larger than 1 cu. yd. ,increase mixing time by 15 seconds for each additional 1 cu. yd.
3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

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PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine subbase surfaces for compliance with requirements for dimensional, slope, and elevation tolerances.

B. Proof-roll prepared subbase surface below decorative concrete paving to identify soft pockets and areas of excess yielding.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove loose material from subbase surface immediately before placing concrete.

B. Protect adjacent construction from discoloration and spillage during application of color hardeners, release agents, stains, curing compounds, and sealers.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.5 JOINTS

A. General:
   1. Jointing details and materials should be consistent with adjacent cement concrete paving, as practical.

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2. Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
2. Butt Joints: Use bonding agent or epoxy bonding adhesive at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
3. Dowelled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 20 feet unless otherwise indicated.
2. Extend joint fillers full width and depth of joint.
3. Terminate joint filler not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished surface if joint sealant is indicated.
4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
7. Install backer material as required to support sealant and at a cross sectional shape to allow maximum sealant movement.
8. Seal joints with approved joint sealant per manufacturer's instructions. Remove excess sealant from sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows, to match jointing of adjacent concrete paving:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch (6-mm) radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.

2. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 3/8-inch (10-mm) radius. Repeat tooling of edges after applying surface finishes. Eliminate edging tool marks on concrete surfaces.

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3.6 CONCRETE PLACEMENT

A. See Section 32 13 13 “Concrete Paving”.

B. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.7 FLOAT FINISHING

A. See Section 32 13 13 “Concrete Paving”.

3.8 CONCRETE PROTECTION AND CURING

A. See Section 32 13 13 “Concrete Paving”

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Conform to requirements of Section 033000 “Cast In Place Concrete”

3.10 REPAIRS AND PROTECTION

A. Remove and replace decorative concrete paving that is broken or damaged or does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Detailing: Grind concrete "squeeze" left from tool placement. Color ground areas with slurry of color hardener mixed with water and bonding agent. Remove excess release agent with high-velocity blower.

C. Protect decorative concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain decorative concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION

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SECTION 32 13 73

CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cold-applied joint sealants.
2. Hot-applied joint sealants.

B. Related Sections:

1. Section 32 12 16 "Asphalt Paving" for constructing joints between concrete and asphalt pavement.
2. Section 32 13 13 "Concrete Paving" for constructing joints in concrete pavement.

1.3 PRECONSTRUCTION TESTING

A. See DelDOT Standard Specifications Sections 400, 500 and 1042 for requirements.

1.4 ACTION SUBMITTALS

A. Product Data: For each joint-sealant product indicated.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Product Certificates: For each type of joint sealant and accessory, from manufacturer.

C. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for joint sealants.

D. Preconstruction Compatibility and Adhesion Test Reports: From joint-sealant manufacturer, indicating the following:

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1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility with and adhesion to joint sealants.
2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Source Limitations: Obtain each type of joint sealant from single source from single manufacturer.

C. Product Testing: Test joint sealants using a qualified testing agency.

1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated.

D. Preinstallation Conference: Conduct conference at Project site.

1.7 PROJECT CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or as specified in DelDOT Standard and Specifications, Sections 400, 500 and 1042.
2. When joint substrates are wet.
3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.

B. Colors of Exposed Joint Sealants: As indicated by manufacturer's designations.

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2.2 COLD-APPLIED JOINT SEALANTS

A. See DelDOT Standard Specifications, Sections 400, 500, and 1042 for requirements.

2.3 HOT-APPLIED JOINT SEALANTS

A. See DelDOT Standard Specifications, Sections 400, 500, and 1042 for requirements.

2.4 JOINT-SEALANT BACKER MATERIALS

A. General: Provide joint-sealant backer materials that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint-sealant manufacturer based on field experience and laboratory testing.

B. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

C. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

D. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D 5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.5 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

PART 3 - EXECUTION

3.1 Examine, prepare, install, clean and protect all joints and joint sealants in accordance with DelDOT Standard Specifications, Sections 400, 500, and 1042.

END OF SECTION

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SECTION 32 17 23

PAVEMENT MARKINGS

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes painted markings applied to asphalt and concrete pavement.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to marking pavement including, but not limited to, the following:

a. Pavement aging period before application of pavement markings.
b. Review requirements for protecting pavement markings, including restriction of traffic during installation period.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include technical data and tested physical and performance properties.

B. Shop Drawings: For pavement markings.

1. Indicate pavement markings, colors, lane separations, defined parking spaces, and dimensions to adjacent work.
2. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of Delaware Department of Transportation for pavement-marking work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature as required by Delaware Department of Transportation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: As approved by Delaware Department of Transportation.

2.2 PAVEMENT-MARKING PAINT

A. Pavement-Marking Paint: See DelDOT Specification Section 1071 for material requirements.

1. Color: As indicated on drawings.

B. Glass Beads: See DelDOT Specification Section 1071.

C. VOC Content: See DelDOT Specification Section 1071.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement is dry and in suitable condition to begin pavement marking according to manufacturer's written instructions.

B. Proceed with pavement marking only after unsatisfactory conditions have been corrected.

3.2 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Allow paving to age for a minimum of 2 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

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D. Apply all pavement markings, symbols and glass beads according to DelDOT Specifications Section 1071.

3.3 PROTECTING AND CLEANING

A. Protect pavement markings from damage and wear during remainder of construction period.

B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION

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SECTION 32 18 13

SYNTHETIC GRASS SURFACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes synthetic grass surfacing with cushion layer.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For synthetic grass surfacing.

1. Include sections and details.
2. Show locations of seams and method of seaming.

C. Samples: For each type of synthetic grass surfacing indicated.

1. Turf Fabric: 12 inches square.
2. Infill Material: 4 oz. of each type.
3. Seam Sample: 24 inches square with seam centered in sample.
4. Cushion material

1.5 INFORMATIONAL SUBMITTALS

A. Product Test Reports: For each synthetic grass surfacing assembly.

B. Sample Warranties: For special warranties.

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1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For synthetic grass surfacing, including maintenance cleaning instructions, to include in maintenance manuals.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store materials in location and manner to allow installation of synthetic grass surfacing without excess disturbance of granular base.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace synthetic grass surfacing that fails in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Deterioration and excessive wear.
b. Deterioration from UV light.
c. Seam separation.

2. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYNTHETIC GRASS SURFACING

A. Synthetic Grass Surfacing: Complete surfacing system, consisting of synthetic yarns bound to water-permeable backing and infill indicated, suitable for roof deck installation.

B. Manufacturers:
1. Lawn
a. Basis-of-design: Subject to compliance with the requirements, provide SynLawn or a comparable product by one of the following, or equal as approved by the Professional:
1) XGrass: Ready Putt
2) Megagrass; Megagolf

b. BOD Product name: SynLawn
1) Product: Classic Pitch
2) Pile Height: 7/8”
3) Pile Weight: 53 oz.
4) Color: Verde
5) Material: 100% Nylon with Heatblock Technology
6) Infill: sand

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C. Sand Infill: Uniformly sized silica sand free of silts, clays, and contaminants, and of subangular or rounder shape according to ASTM F1632; mesh size as recommended by synthetic grass surfacing manufacturer.

1. Infill Proportions: Manufacturer's standard proportions for rooftop installations.

D. Seaming Method: Adhesive.

E. Cushion / shock pad material:
1. Manufacturer: Brock, or approved equal
2. Product: Shock Pad series

2.2 MATERIALS

A. Seam Adhesive: One- or two-part urethane, recommended or approved by synthetic grass surfacing manufacturer, and suitable for ambient conditions at time of installation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine base and other conditions, with Installer present, for compliance with requirements for installation tolerances, permeability, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Avoid disturbance of base during installation of turf fabric.

B. Roll out turf fabric and allow to relax at least four hours prior to seaming.

C. Provide seams flat and snug, with no gaps or fraying. Remove yarns that are trapped within seams. Attach turf fabric to perimeter restraint system as recommended by the manufacturer.

D. Repair loose seams and bubbles formed due to expansion of turf fabric prior to installation of infill.

E. Evenly broadcast and groom infill by machine in proportions and depth after settling as recommended by the manufacturer, and to meet indicated performance requirements. Rake fibers trapped by infill to surface.

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3.3 DEMONSTRATION

A. Train Owner's maintenance personnel in proper maintenance procedures for synthetic grass surfacing.

END OF SECTION 32 18 13

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SECTION 32 18 16

SAFETY SURFACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Unitary, seamless surfacing.

1.3 DEFINITIONS

A. Critical Height: Standard measure of shock attenuation according to ASTM F 2223; same as "critical fall height" in ASTM F 1292.

B. Unitary Surfacing: A protective surfacing of one or more material components bound together to form a continuous surface; same as "unitary system" in ASTM F 2223.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of protective surfacing.
1. Include plans, sections, placement details, and attachment to substrates.
2. Include accessories and edge terminations.

C. Samples: For each exposed product and for each color and texture specified.

D. Samples for Initial Selection: For each type of exposed finish.
1. Include Samples of accessories involving color selection.

1.5 INFORMATIONAL SUBMITTALS

A. Material certificates.

B. Product certificates.

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C. Certificate of qualifications of the playground surfacing installer

D. Field quality-control reports.

E. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For playground protective surfacing to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.8 WARRANTY

A. Special Warranty: Manufacturer and Installer agree to repair or replace components of protective surfacing that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Reduction in impact attenuation as measured by reduction of critical fall height.
      b. Deterioration of protective surfacing and other materials beyond normal weathering.
   2. Warranty Period: Ten years from date of Substantial Completion, minimum.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Impact Attenuation: Critical fall height tested according to ASTM F 1292.

B. Gmax: less than 200

C. Head Injury Criteria: Less than 1000

D. Flammability (ASTM D2859): Pass

E. Tensile Strength (ASTM D412): 60 psi (413 lPa).

F. Tear Resistance (ASTM D624): 140%

G. Water Permeability: 0.4 gal/yd2/second.

H. Accessibility Standard: Minimum surfacing performance according to ASTM F 1951.

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2.2 UNITARY, DUAL-DENSITY, SEAMLESS SURFACING

A. Description: Manufacturer's standard, site-mixed and applied, two-layer material with wearing layer over cushioning layer, with combined, overall thickness as required, tested for impact attenuation according to ASTM F 1292 and for accessibility according to ASTM F 1951.
   1. Manufacturer:
      a. Basis of Design: Surface America.
         1) Playbound with Extreme-10 system
      b. Acceptable manufacturers:
         1) SpectraTurf
         2) No-fault Surfaces
   2. Color: to be selected from manufacturers full range; assume one solid colors (no black).
   3. Wearing Layer: Formulation of EPDM rubber particles or polyurethane granules, binder, and other organic and inorganic components.
   4. Cushioning Layer: Formulation of 100% recycled SBR particles and binder.
   5. Binder: Weather-resistant, UV-stabilized, flexible, nonhardening, 100 percent solids aliphatic polyurethane.
   6. Lacquer Topcoat: Manufacturer's standard polyurethane-based formulation.
   7. Critical Height: .Fall from standing adult
   8. Overall Thickness: Not less than.required for critical height indicated.
   9. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location.
   10. Wearing Layer Color(s): .As selected by Architect from manufacturer’s full range.

B. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

PART 3 - .EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for subgrade elevations, slope, and drainage and for other conditions affecting performance of the Work.
   1. Verify that substrates are sound and without high spots, ridges, holes, and depressions.

B. Hard-Surface Substrates: Verify that substrates are satisfactory for unitary, protective surfacing installation and that substrate surfaces are dry, cured, and uniformly sloped to drain within recommended tolerances according to protective surfacing manufacturer's written requirements for cross-section profile.
   1. Asphalt Substrates: Verify that substrates are dry, sufficiently cured to bond with adhesive, and free from surface defects, dust, dirt, loose particles, grease, oil, and other contaminants incompatible with protective surfacing or that may interfere with adhesive bond.
   2. Concrete Substrates: Verify that substrates are dry and free from surface defects, laitance, glaze, efflorescence, curing compounds, form-release agents, hardeners, dust, dirt, loose particles, grease, oil, and other contaminants incompatible with protective surfacing or

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that may interfere with adhesive bond. Determine adhesion, dryness, and acidity characteristics by performing procedures recommended in writing by protective surfacing manufacturer.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrates to receive surfacing products according to protective surfacing manufacturer's written instructions.

B. Hard-Surface Substrates: Clean surface free of laitance, efflorescence, curing compounds, and other contaminants incompatible with protective surfacing.
   1. Repair: Fill holes and depressions in unsatisfactory surfaces with leveling and patching material.
   2. Treatment: Mechanically abrade or otherwise prepare concrete substrates according to protective surfacing manufacturer's written instructions to achieve adequate roughness.
   3. Terminal Edges: Saw cut concrete or asphalt for terminal edges of protective surfacing.
   4. Treat control joints and other nonmoving substrate cracks to prevent telegraphing through protective surfacing.

3.3 INSTALLATION OF SEAMLESS SURFACING

A. Mix and apply components of seamless surfacing according to manufacturer's written instructions to produce uniform, monolithic, and impact-attenuating protective surfacing of required overall thickness.
   1. Substrate Primer: Apply over prepared substrate at manufacturer's standard spreading rate for type of substrate.
   2. Poured Cushioning Layer: Spread evenly over primed substrate to form a uniform layer applied at manufacturer's standard spreading rate, 29 pounds 1 oz. per cf, in one continuous operation, with a minimum of cold joints.
   3. Intercoat Primer: Over cured cushioning layer, apply primer at manufacturer's standard spreading rate, 300 ft2/gal.
   4. Wearing Layer: Spread over primed base course to form a uniform layer applied at manufacturer's standard spreading rate, 58 poinds, 9 oz. per cf, in one continuous operation and, except where color changes, with no cold joints. Finish surface to produce manufacturer's standard wearing-surface texture.
      a. Design: Where colored pattern is required, place colored, design material as soon as previously placed material is sufficiently cured, using primer or adhesive if required by manufacturer's written instructions.
   5. Edge Treatment: As indicated on Drawings. Fully adhere edges to substrate with full coverage of substrate. Maintain fully cushioned thickness required to comply with performance requirements.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests.

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B. Perform the following tests with the assistance of a factory-authorized service representative:
   1. Perform "Installed Surface Performance Test" according to ASTM F 1292 for each protective surfacing type and thickness in each playground area.

C. Playground protective surfacing will be considered defective if it does not pass tests.

D. Prepare test reports.

3.5 PROTECTION

A. Prevent traffic over seamless surfacing for not less than 48 hours after installation.

END OF SECTION 321816

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SECTION 32 31 13

CHAIN LINK FENCES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Chain-link fences with slats

B. Related Requirements:

1. Section 03 30 00 "Cast-In-Place Concrete" for and post footings.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Fence, rails, and fittings.
b. Chain-link fabric, reinforcements, and attachments.
c. Slats

B. Shop Drawings: For each type of fence and gate

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include accessories and hardware.
3. Include grounding requirements and details.

C. Samples for Verification: For each type of component with factory-applied finish, prepared on Samples of size indicated below:

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1. Polymer-Coated Components: In 6-inch lengths

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For factory-authorized service representative or professional engineer.

B. Product Certificates: For each type of chain-link fence and netting.

C. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For fencing

1.7 FIELD CONDITIONS

A. Field Measurements: Verify layout information for chain-link fences shown on Drawings in relation to adjacent improvements. Verify dimensions by field measurements.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of chain-link fences and netting system that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Failure to comply with performance requirements.
b. Deterioration of metals, metal finishes, netting and other materials beyond normal weathering.

2. Warranty Period: Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer for chain link fencing: basis of design: Master Halco or approved equal,
1. Type: Color chain link fencing
a. Product: Permafused; fused and adhered vinyl coating

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2.2 CHAIN-LINK FENCE FABRIC

A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist according to "CLFMI Product Manual" and requirements indicated below:

1. Fabric Height: As indicated on Drawings.
2. Steel Wire for Fabric: 8 gauge finish with 9 gauge wire core

a. Mesh Size: 2” or as required for pre-installed privacy slats.
b. Polymer-Coated Fabric: ASTM F668, Class 2a, over zinc or Zn-5-Al-MM-alloy-coated steel wire.

1) Color: Black, according to ASTM F934.

c. Coat selvage ends of metallic-coated fabric before the weaving process with manufacturer's standard clear protective coating.

3. Selvage: Knuckled at both selvages; knuckle/knuckle, no pointed prongs

2.3 FENCE FRAMEWORK

A. Posts and Rails: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F1043 based on the following:

1. Fence Height: As indicated on Drawings.
2. Light-Industrial-Strength Material

3. Horizontal Framework Members: top and bottom rails according to ASTM F1043.

2.4 SWING GATES

A. General: ASTM F900 for gate posts and double swing gate types.

1. Gate Leaf Width: 72” each leaf

2. Gate post: 4” outside diameter

B. Hardware:

1. Hinges: 360-degree inward and outward swing.
2. Latch: Permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.
3. Lock: Manufacturer's standard internal device.
4. Gate holdback: Provide galvanized drop rod with center gate for each gate leaf. Gate keeper shall consist of mechanical device for securing free end of gate when in full open position.

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2.5 PRIVACY SLATS

A. Tubular Polyethylene Slats: Minimum 0.023-inch (0.58-mm)-thick tubular polyethylene, manufactured for chain-link fences from virgin polyethylene with UV inhibitor, sized to fit mesh specified for direction indicated, with vandal-resistant fasteners and lock strips.
1. Product: SlatMaster Privacy Slats; preinstalled onto mesh fabric.

B. Color: Black

2.6 GROUNDING MATERIALS

A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connectors and Grounding Rods: Listed and labeled for complying with UL 467.

1. Connectors for Below-Grade Use: Exothermic welded type.
2. Grounding Rods: Copper-clad steel, 5/8 by 96 inches (16 by 2440 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet (152 m) or line of sight between stakes.

3.3 CHAIN-LINK FENCE INSTALLATION

A. Install chain-link fencing according to ASTM F567 and more stringent requirements specified.

B. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.

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2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect above ground portion of posts from concrete splatter.

C. Chain-Link Fabric: Apply fabric to field side of enclosing framework. Leave **2-inch** bottom clearance between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

D. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts, with tension bands spaced not more than 15 inches o.c.

E. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric according to ASTM F626. Bend ends of wire to minimize hazard to individuals and clothing.

1. Maximum Spacing: Tie fabric to line posts at 12 inches (300 mm) o.c. and to braces at 24 inches (610 mm) o.c.

F. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

3.4 GROUNDING AND BONDING

A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Fence and Netting Post Grounding:
1. Fences within 100 Feet (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet (225 m).
2. Ground fence on each side of fence openings.

C. Connections:

1. Make connections with clean, bare metal at points of contact.
2. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
3. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
4. Make above-grade ground connections with mechanical fasteners.
5. Make below-grade ground connections with exothermic welds.
6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

END OF SECTION 32 31 13

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SECTION 32 31 19

DECORATIVE METAL FENCES

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Decorative aluminum fences and gates

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design decorative fences and gates, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
1. Provide fencing system including top and bottom rails, single and double swing gates with appropriate cross bracing and post size, post caps, closing and locking hardware.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Shop Drawings: For fence panels and gates. Include plans, elevations, sections, details, hardware and attachments to other work. Include diagrams for power, signal, and control wiring.

B. Samples: For each fence material and for each color specified.

1.4 DELIVERY, STORAGE AND HANDLING

A. Provide manufacturer’s standard limited warranty that its ornamental fence system is free from defects in material and workmanship including cracking, peeling, blistering and corroding for a period of 15 years from the date of purchase.

PART 2 - PRODUCTS

2.1 DECORATIVE ALUMINUM FENCES

A. Decorative Aluminum Fences: Fences made from aluminum extrusions for commercial applications.

1. Basis-of-Design Product: Subject to compliance with requirements, provide fencing from the following manufacturer: Ameristar / Assa Abloy, Echelon II, or equal as approved by the Professional:

   a. Master Halco

   b. Jerith Manufacturing

B. Posts: Square extruded tubes, 2.5 by 2.5 inches minimum; post size varies per height per manufacturers with 0.093-inch wall thickness.

C. Post Caps: Aluminum castings.

D. Rails: Extruded-aluminum channels
   a. 6 foot fence and gate: two rail, as indicated on Drawings

E. Pickets: Extruded-aluminum tube
   a. 6 foot fence and gate: as indicated on Drawings

2. Picket Spacing: 4 inches clear, maximum.

F. Fasteners: Manufacturer's standard tamperproof, corrosion-resistant, color-coated fasteners matching fence components.

G. Fabrication: Assemble fences into sections by fastening pickets to rails.

2.2 SWING GATES

A. Aluminum Frames and Bracing: Fabricate members from square extruded-aluminum tubes with wall thickness.

B. Hardware: Exterior hardware to be key card access. Courtyard interior to be panic bar hardware connected to security system.

C. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.

D. Aluminum Finish: Baked enamel or powder coating.

2.3 MISCELLANEOUS MATERIALS

A. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Section 03 30 00 "Cast-in-Place Concrete" with a minimum 28-day compressive strength of 3000 psi, 3-inch slump, and 1-inch maximum aggregate size.

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2.4 GROUNDING MATERIALS

A. Grounding Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.

1. Material above Finished Grade: Aluminum.
2. Material on or below Finished Grade: Copper.

B. Grounding Connectors and Grounding Rods: Comply with UL 467.

2.5 ALUMINUM FINISHES

A. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 2 mils. Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

1. Color and Gloss: Bronze

PART 3 - EXECUTION

3.1 DECORATIVE FENCE INSTALLATION

A. Install fences according to manufacturer's written instructions.

B. Post Setting in concrete footings: Set posts in concrete footings at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Extend post to within 6 inches of specified excavation depth, but not closer than 3 inches to bottom of concrete.
3. Space posts uniformly at 8 feet o.c. or as indicated on drawings.

C. Posts Set into Concrete in Sleeves: Use galvanized-steel pipe sleeves with inside diameter at least 3/4 inch larger than outside diagonal dimension of post, preset and anchored into concrete for installing posts.
1. Extend posts at least 5 inches into sleeve.
2. After posts have been inserted in sleeves, fill annular space between post and sleeve with nonshrink grout, mixed and placed to comply with grout manufacturer's written instructions; shape and smooth to shed water. Finish and slope top surface of grout to drain water away from post.

3.2 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install

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ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.3 GROUNDING AND BONDING

A. Fence Grounding: Install at maximum intervals of 1500 feet except as follows:

1. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.

a. Gates and Other Fence Openings: Ground fence on each side of opening. Bond metal gates to gate posts.

B. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

C. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

D. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

E. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

END OF SECTION 32 31 19

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SECTION 32 33 00

SITE FURNISHINGS

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, specifications and general prov1s10ns of Contract, including General and Supplementary Conditions and other Division-I Specification Sections, apply to this Section.

1.2 SUMMARY

B. Section includes
   1. Benches
   2. Trash Receptacle
   3. Planters
   4. Television
   5. Bike Rack
   6. Shed
   7. Outdoor Fan
   8. Bird House

1.3 ACTION SUBMITTALS

C. Product Data: Manufacturer's product data for each type of product. Samples of materials requiring color or fabric selection.

D. Samples for Verification: For each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

E. Installation manuals

F. Maintenance manuals

PART 2 - PRODUCTS

2.1 BENCH

A. Products:

   1. Public entrances, courtyards and pathways

a. Basis-of-design: Subject to compliance with the requirements, provide Anova Elevation or a comparable product by one of the following, or equal as approved by the Professional:
   1) Victor Stanley Stell; with armrests; recycled plastic
   2) Maglin 970 Backed Bench; with armrests; high density paper composite

b. BOD Product name: Anova
   1) Style: Elevation 6' Recycled Plastic Bench with arms
   2) Length – 72"
   3) Steel: Hot-dip galvanized and powder-coated
   4) Color (metal frame): Textured Pewter
   5) Recycled Plastic: Cedar
   6) Installation: Surface mount

2.2 TRASH RECEPTACLE

A. Products:

1. Public entrances, courtyards
   a. Basis-of-design: Subject to compliance with the requirements, provide Anova Elevation 45 gallon or a comparable product by one of the following, or equal as approved by the Professional:
      1) Victor Stanley Ren Top-Deposit; 45 gallon; Recycled Plastic
      2) Maglin 1050 Trash Container; high density paper composite

   b. BOD Product name: Anova
      1) Style: Mixx 33 Gallon Recycled Plastic Receptacle
      2) Size: 33 Gallon
      3) Steel: Hot-dip galvanized and powder-coated
      4) Color (metal frame): Textured Pewter
      5) Recycled Plastic: Cedar
      6) Installation: Surface mount

2.3 PLANTERS

B. Products: Accessible / raised planters
   a. Basis-of-design: Subject to compliance with the requirements, provide Accessible Gardens or a comparable product by one of the following, or equal as approved by the Professional:
      1) Gardener's Supply VegTrug Patio Garden
      2) World of Greenhouses ADA Wheelchair Accessible Cedar Garden Bed

2. BOD Product:
   a. Material: Cedar
   b. Model: ADA-Compliant Forward Facing Wheelchair Garden
   c. Height: 30"

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2.4 EXTERIOR TELEVISION

A. Products:

a. Basis-of-design: Subject to compliance with the requirements, provide Samsung or a comparable product by one of the following, or equal as approved by the Professional:
1) Sunbrite TV 55" Pro Series Ultra-Bright Outdoor TV

b. Product: Samsung
1) Model: 55" Class Outdoor QLED Smart TV
2) Name: The Terrace Partial Sun
3) Wall Mount: The Terrace Wall Mount

2.5 BIKE RACK

A. Products:

a. Basis-of-design: Subject to compliance with the requirements, provide Anova or a comparable product by one of the following, or equal as approved by the Professional:
1) Victor Stanley; Cycle Sentry Collection; BRCA-101
2) Maglin: SC Bike Racks; 1600 Series

b. BOD Product: Anova
1) Model: Allure Bike Rack
2) Color: Textured Pewter
3) Installation: Surface mount per manufacturer's instructions.

2.6 SHED

A. Products:

a. Basis-of-design: Subject to compliance with the requirements, provide Arrow Sheds or a comparable product by one of the following, or equal as approved by the Professional:
1) DuraMax; 8' wide x 6' depth; Pent roof metal shed kit
2) Canopia by Palram; 6' wide x 8' depth
3) Color: Cool grey

b. BOD Product: Arrow
1) Arrow 8'wide x 6' depth Elite Steel Storage Shed
2) Model: EG86CG
3) Color: Cool grey
.

2.7 OUTDOOR FAN

A. Products:

a. Basis-of-design: Subject to compliance with the requirements, provide Minka Aire or a comparable product by one of the following, or equal as approved by the Professional:

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1) Big Ass Fans
2) Hunter Outdoor Fans

b. BOD Product: Minka Aire
1) Product name: Java exterior fan
2) Model: F753-CL

2.8 BIRD HOUSE

A. Products:

a. Basis-of-design: Subject to compliance with the requirements, provide Vestre or a comparable product by one of the following, or equal as approved by the Professional:
1) Duncraft; Wren Cabin Bird House; Heaavy Duty sectional Pole
2) Bestnest; Heartwood Copper Songbird Deluxe

b. BOD Product: Vestre
1) 5824 wings, Wide bird house
2) 5827C Wings, 2m mounting pole
3) Installation: Concrete footing

PART 3 -EXECUTION

3.1 INSTALLATION

1. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.
2. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.
3. Install site furnishings level, plumb, true, and securely anchored or positioned at locations indicated on Drawings.

END OF SECTION

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SECTION 32 84 00

PLANTING IRRIGATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes: performance requirements for design and installation of complete planting and green roof irrigation system

1.3 PERFORMANCE REQUIREMENTS

A. Provide all components required for a high efficiency, weather-based irrigation system, utilizing drip, micro misters and subsurface irrigation where applicable, soil moisture, rainfall sensors, weather station, and smart controllers throughout.

B. Irrigation zone control shall be automatic operation with controller and automatic control valves.

C. Delegated Design: Design 100 percent coverage irrigation system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

D. Provide irrigation to all shrub and perennial beds.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation. Submit complete shop drawings to include all irrigation system components including controllers, valves, piping and tubing, emitters, misters, spray heads, valve boxes, etc. Show each irrigation zone and its control valve.

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1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Irrigation systems, drawn to scale, on which components are shown and coordinated with each other, using input from Installers of the items involved. Also include adjustments necessary to avoid plantings and obstructions.

B. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sprinklers controllers and automatic control valves to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer,

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.9 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Construction Manager Owner no fewer than four days in advance of proposed interruption of water service.
2. Do not proceed with interruption of water service without Construction Manager's , Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Comply with requirements in the piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

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B. Galvanized-Steel Pipe: ASTM A 53/A 53M, Standard Weight, Type E, Grade B.

C. Ductile-Iron Pipe with Mechanical Joints: AWWA C151, with mechanical-joint bell and spigot ends.

D. Ductile-Iron Pipe with Push-on Joint: AWWA C151, with push-on-joint bell and spigot ends.

E. Soft Copper Tube: ASTM B 88, Type L, water tube, annealed temper.

F. Hard Copper Tube: ASTM B 88, Type L, and ASTM B 88, Type M, water tube, drawn temper.

G. PE Pressure Pipe: AWWA C906, with DR of 7.3, 9, or 9.3 and PE compound number required to give pressure rating not less than 160 psig.

H. PVC Pipe: ASTM D 1785, PVC 1120 compound, Schedules 40 and 80.

2.2 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick unless otherwise indicated; full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.3 AUTOMATIC CONTROL VALVES

A. Bronze, Automatic Control Valves:

1. Description: Cast-bronze body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.

2.4 AUTOMATIC DRAIN VALVES

A. Description: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below 2-1/2 to 3 psig.

2.5 TRANSITION FITTINGS

A. General Requirements: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

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2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

2.7 SPRINKLERS

A. General Requirements: Designed for uniform coverage over entire spray area indicated at available water pressure.

2.8 QUICK COUPLERS

A. Description: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap; hose swivel with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet; and operating key.

2.9 DRIP IRRIGATION SPECIALTIES

A. Freestanding Emitters: Device to deliver water at approximately 20 psig.

B. Manifold Emitter Systems: Manifold with tubing and emitters.

C. Multiple-Outlet Emitter Systems: Emitter with tubing and button-type outlets.

D. Drip Tubes with Direct-Attached Emitters:

E. Drip Tubes with Remote Discharge:

F. Off-Ground Supports: Plastic stakes.

G. Application Pressure Regulators: Brass or plastic housing, NPS 3/4, with corrosion-resistant internal parts; capable of controlling outlet pressure to approximately 20 psig.

H. Filter Units: Brass or plastic housing, with corrosion-resistant internal parts; of size and capacity required for devices downstream from unit.

I. Air Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

J. Vacuum Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

2.10 CONTROLLERS

A. Description:

1. Weather based controller for Automatic Control Valves: Each station is variable from approximately 5 to 60 minutes. Include switch for manual or automatic operation of each station.

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2. Weather / climate based sensors to include soil moisture sensors, rainfall sensors, or connection to a weather station; with the abilbity to interrupt or modify irrigation schedules.
3. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof, with locking cover and two matching keys; include provision for grounding.

    a. Body Material: Stainless-steel sheet metal.

4. Interior Control Enclosures: NEMA 250, Type 12, dripproof, with locking cover and two matching keys.

    a. Body Material: Stainless-steel sheet metal.

5. Control Transformer: 24-V secondary, with primary fuse.

6. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily.

    a. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
    b. Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.
    c. Surge Protection: Metal-oxide-varistor type on each station and primary power.

2.11 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:

1. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.

B. Polymer-Concrete Boxes:

1. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.

C. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3/4 inch minimum to 3 inches maximum.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

B. Install warning tape directly above pressure piping, 12 inches below finished grades, except 6 inches below subgrade under pavement and slabs.

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C. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from 3/4 to 3 inches, to below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.

3.2 PIPING INSTALLATION

A. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.

B. Install piping free of sags and bends.

C. Install groups of pipes parallel to each other, spaced to permit valve servicing.

D. Install fittings for changes in direction and branch connections.

E. Install unions adjacent to valves and to final connections to other components with NPS 2 or smaller pipe connection.

F. Install flanges adjacent to valves and to final connections to other components with NPS 2-1/2 or larger pipe connection.

G. Install underground thermoplastic piping according to ASTM D 2774.

H. Install expansion loops in control-valve boxes for plastic piping.

I. Lay piping on solid subbase, uniformly sloped without humps or depressions.

J. Install PVC piping in dry weather when temperature is above 40 deg F. Allow joints to cure at least 24 hours at temperatures above 40 deg F before testing.

K. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet. Install aboveground or in control-valve boxes.

L. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.

M. Install piping in sleeves under parking lots, roadways, and sidewalks.

N. Install sleeves made of Schedule 80 PVC pipe and socket fittings, and solvent-cemented joints.

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

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1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Flanged Joints: Select rubber gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

E. Ductile-Iron Piping Gasketed Joints: Comply with AWWA C600 and AWWA M41.

F. Copper-Tubing Brazed Joints: Construct joints according to CDA's "Copper Tube Handbook," using copper-phosphorus brazing filler metal.

G. Copper-Tubing Soldered Joints: Apply ASTM B 813 water-flushable flux to tube end unless otherwise indicated.

3.4 VALVE INSTALLATION

A. Underground Curb Valves: Install in curb-valve casings with tops flush with grade.

B. Underground Iron Gate Valves, Resilient Seat: Comply with AWWA C600 and AWWA M44. Install in valve casing with top flush with grade.

1. Install valves and PVC pipe with restrained, gasketed joints.

C. Aboveground Valves: Install as components of connected piping system.

D. Pressure-Reducing Valves: Install in boxes for automatic control valves or aboveground between shutoff valves.

E. Throttling Valves: Install in underground piping in boxes for automatic control valves.

F. Drain Valves: Install in underground piping in boxes for automatic control valves.

3.5 SPRINKLER INSTALLATION

A. Install sprinklers after hydrostatic test is completed.

B. Install sprinklers at manufacturer's recommended heights.

C. Locate part-circle sprinklers to maintain a minimum distance of 4 inches from walls and 2 inches from other boundaries unless otherwise indicated.

3.6 DRIP IRRIGATION SPECIALTY INSTALLATION

A. Install freestanding emitters on pipe riser to mounting height indicated.

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B. Install manifold emitter systems with tubing to emitters. Plug unused manifold outlets. Install emitters on off-ground supports at height indicated.

C. Install multiple-outlet emitter systems with tubing to outlets. Plug unused emitter outlets. Install outlets on off-ground supports at height indicated.

D. Install drip tubes with direct-attached emitters on ground.

E. Install drip tubes with remote-discharge on ground with outlets on off-ground supports at height indicated.

F. Install off-ground supports of length required for indicated mounted height of device.

3.7 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.

1. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Section 312000 "Earth Moving" for warning tapes.

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation. Confirm that weather based components are operational.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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D. Any irrigation product will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that controllers are installed and connected according to the Contract Documents.
3. Verify that electrical wiring installation complies with manufacturer's submittal.

3.10 ADJUSTING

A. Adjust settings of controllers.

B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.

C. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with, or not more than 1/2 inch above, finish grade.

3.11 CLEANING

A. Flush dirt and debris from piping before installing sprinklers and other devices.

3.12 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain automatic control valves and controllers.

END OF SECTION 32 84 00

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SECTION 32 91 13

SOIL PREPARATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes planting soils specified by composition of the mixes, for planting on grade.

B. Related Requirements:
1. Section 32 92 00 “Lawns” for seeding and sodding.
2. Section 32 93 00 "Planting" for planting.

1.3 DEFINITIONS

A. Imported Soil: Soil that is transported to Project site for use.

B. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

C. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

D. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

E. Imported Soil: Soil that is transported to Project site for use.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each bulk-supplied material, 1/2-gallon volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

NOT FOR BIDDING PURPOSES

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed, and will provide recommendations for soil amendments.

1.7 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction soil analyses on existing, on-site soil, imported soil and compost. .

B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.

1.8 EXISTING SOIL-SAMPLING REQUIREMENTS

A. General: Extract soil samples according to requirements in this article.

B. Sample Collection and Labeling: Have samples taken and labeled by state-certified, licensed, or registered soil scientist or landscape contractor under the direction of the testing agency.

1. Number and Location of Samples:
   a. After rough grading is complete and at subgrade elevation and before placement of planting soil, collect a minimum of ten representative soil samples from varied locations for each soil to be used or amended for landscaping purposes.
   b. Provide a minimum of two representative soil samples from stockpiled topsoil if available.
2. Procedures and Depth of Samples: per instructions from the testing laboratory.
3. Division of Samples: Split each sample into two, equal parts. Send half to the testing agency and half to Owner for its records.
4. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.9 IMPORTED SOIL,COMPOST AND PLANTING SOIL MIX TESTING

A. Provide soil test results and recommendations for all imported topsoil, manufactured planting soil and compost per Testing Requirements article.

B. Provide soil test and recommendations for each 500 CY of imported topsoil, and planting soil.

C. Provide soil test and recommendations for each planting soil mix per article 2.3 Planting Soils by Composition.

NOT FOR BIDDING PURPOSES

1.10 TESTING REQUIREMENTS

A. General: Perform tests on soil samples according to requirements in this article.

B. Physical Testing:

1. Soil Texture: Soil-particle, size-distribution analysis by one of the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":

a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
b. Hydrometer Method: Report percentages of sand, silt, and clay.

2. CEC: Analysis by sodium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."

C. Fertility Testing: Soil-fertility analysis according to standard laboratory protocol of , including the following:

1. Percentage of organic matter.
2. CEC, calcium percent of CEC, and magnesium percent of CEC.
3. Soil reaction (acidity/alkalinity pH value).
4. Buffered acidity or alkalinity.
5. Nitrogen ppm.
6. Phosphorous ppm.
7. Potassium ppm.
8. Manganese ppm.
9. Manganese-availability ppm.
10. Zinc ppm.
11. Zinc availability ppm.
12. Copper ppm.
13. Sodium ppm.
14. Soluble-salts ppm.

D. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."

E. Compost testing: Also provide C:N ratio.

F. Recommendations: *Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated.* Include, at a minimum, recommendations for compost, nitrogen, phosphorous, and potassium fertilization, and for micronutrients. Provide recommendations for addition of organic compost in lieu of inorganic fertilizer.

1. Fertilizers and Soil Amendment Rates: State recommendations in weight per 1000 sq. ft. for 6-inchdepth of soil.
2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight per 1000 sq. ft. for 6-inch depth of soil .

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1.11 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Do not move or handle materials when they are wet or frozen.
4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Regional Materials: Imported soil manufactured planting soil and soil amendments and fertilizers shall be manufactured within 500 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site.

2.2 TOPSOIL

A. Imported, naturally formed soil from off-site sources and consisting of sandy loam or loam soil according to USDA textures.

B. Sources: Take imported, unamended soil from sources that are naturally well-drained sites where topsoil occurs at least 4 inches deep, not from agricultural land, bogs, or marshes; and that do not contain undesirable organisms; disease-causing plant pathogens; or obnoxious weeds and invasive plants including, but not limited to, quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and bromegrass.

C. Additional properties of imported topsoil before amending: Soil reaction of pH 6 to 7 and minimum of 2 percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration.

2.3 PLANTING SOILS SPECIFIED BY COMPOSITION

A. General: Soil amendments, fertilizers, and rates of application specified in this article are guidelines that may need revision based on testing laboratory's recommendations after preconstruction soil analyses are performed.

1. Planting-Soil Type: Tree Planting

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a. Mix one half (1/2) existing soil, one quarter (1/4) stockpiled or imported topsoil and one quarter (1/4) compost by volume with additional amendments per soil test recommendations.

2. Planting-Soil Type: Shrub Planting: Same as tree planting.

3. Planting-Soil Type: Lawns: mix three quarters (3/4) stockpiled or imported topsoil with one quarter (1/4) compost.

2.4 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Class: T, with a minimum of 99 percent passing through a No. 8 sieve and a minimum of 75 percent passing through a No. 60 sieve.
2. Class: O, with a minimum of 95 percent passing through a No. 8 sieve and a minimum of 55 percent passing through a No. 60 sieve.
3. Form: Provide lime in form of ground dolomitic limestone.

B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 sieve and a maximum of 10 percent passing through a No. 40 sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a No. 50 sieve.

E. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C 33/C 33M .

2.5 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, Leafgro or approved equal, and as follows:
1. Reaction: pH of 5.5 to 7.
2. Soluble-Salt Concentration: Less than 4 dS/m.
3. Moisture Content: 35 to 55 percent by weight.
4. Carbon:Nitrogen Ratio: less than 25:1
5. Organic-Matter Content: 30 to 40 percent of dry weight.
6. Particle Size: Minimum of 98 percent passing through a 2-inch sieve.

2.6 FERTILIZERS

A. *Apply fertilizer only if recommended by soil testing results.*

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B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:

1. Composition: 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

D. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

PART 3 - EXECUTION

3.1 GENERAL

A. Place planting soil and fertilizers according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.

3.2 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of 6 inches. Remove stones larger than 2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Mixing: Spread unamended soil to total depth of 8 inches, but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.

1. Amendments: Apply soil amendments and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.

a. Mix lime and sulfur with dry soil before mixing fertilizer.
b. Mix fertilizer with planting soil no more than seven days before planting.

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2. Lifts: Apply and mix unamended soil and amendments in lifts not exceeding 8 inches in loose depth for material compacted by compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each blended lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D 698 and tested in-place.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.3 PLACING MANUFACTURED (Pre-Blended) PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply manufactured soil on-site in its final, blended condition. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of 6 inches. Remove stones larger than 2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Application: Spread planting soil to total depth of 8 inches, but not less than required to meet finish grades after natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.

1. Lifts: Apply planting soil in lifts not exceeding 8 inches in loose depth for material compacted by compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D 698.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections:

1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D 698. Space tests at no less than one for each 2000 sq. ft. of in-place soil or part thereof.

C. Soil will be considered defective if it does not pass tests and inspections.

D. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

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3.5 PROTECTION

A. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.
7. Excavation or other digging unless otherwise indicated.

B. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION 32 91 13

NOT FOR BIDDING PURPOSES

SECTION 32 92 00

LAWNS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, specifications and general provisions of Contract, including General and Supplementary Conditions and other Division-I Specification Sections, apply to this Section

1.2 SUMMARY

A. Section Includes:

1. Lawn Seeding.
2. Lawn Sodding.

B. Related Requirements:

1. Section 32 91 13 "Soil Preparation"
2. Section 32 93 00 "Planting"

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 32 91 13 "Soil Preparation".

C. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 INFORMATIONAL SUBMITTALS

A. Certification of grass seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

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B. Certification of each seed mixture for turfgrass sod.

C. Product certificates: For fertilizers, from manufacturer.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required maintenance periods.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf establishment.

1. Experience: Five years' experience in turf installation in addition to requirements in Section 01 40 00 "Quality Requirements."
2. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk materials with appropriate certificates.

1.9 FIELD CONDITIONS

A. Planting Restrictions: Plant during one of the following periods, or as approved by the Landscape Architect due to weather conditions. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.
1. Seeded lawns:
   a. Spring Planting: March 15 – June 1
   b. Fall Planting: September 1– October 15,

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2. Sodded lawns: May be planted unless the ground is frozen or temperatures will exceed 90 degrees F.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

1.10 ACCEPTANCE AND WARRANTY

A. An inspection of work completed shall be conducted by the Landscape Architect and Owner's Representative for the purpose of initial acceptance. Any outstanding items revealed on inspection and identified on the punch list shall be corrected with two weeks. Initial acceptance shall be withheld until those items are completed. Warranty, for a period of one year, shall begin after landscape inspection and initial acceptance.

B. Warrant in writing that all lawns, placed on this Project will remain alive and be in healthy vigorous condition for a period of 1 year after completion and initial acceptance of entire project.

C. During the warranty period replace, in accordance with the drawings and specifications, all lawns that are in an unhealthy or unsightly condition, or more than 25% dead.

D. Final Inspection and Acceptance: An inspection will be conducted with the Landscape Contractor, Landscape Architect and Owner at the end of the one year warranty period for purposes of Final Acceptance.

E. Warranty shall not include damage or loss of plants due to vandalism, fire, severe winds, extreme cold, or negligence on the Owner's part.

F. Owner's maintenance shall begin upon initial acceptance of plant material.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances. Quality, State Certified: State-certified seed of grass species appropriate for solar exposure.

B. Grass-Seed Mix: Provide state certified turf grass blend as follows:
1. 90 – 95% blend of a minimum of three dark green turf-type tall fescue seeds and 10-15% Kentucky Bluegrass.

2.2 TURFGRASS SOD

NOT FOR BIDDING PURPOSES

A. Turfgrass Sod: Certified, Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.
   1. 90 – 95% Tall Fescue blend and 5 – 10% maximum Kentucky Bluegrass

B. Turfgrass Species:
   1. Products: Subject to compliance with requirements, provide the following
   2. Sod of grass species as follows:
      a. Full Sun and Part Shade: Newsom Trio Mix, or approved equal.
      b. Full Shade: Newsom Shade Mix or approved equal

2.3 FERTILIZERS

A. General: Apply fertilizer only if recommended per soil test report recommendations and Section 32 91 13 “Soil Preparation”.

2.4 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

2.5 PESTICIDES

A. General: Do not apply inorganic pesticides.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.
   1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
   2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
   3. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

NOT FOR BIDDING PURPOSES

If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil

3.2 PREPARATION

A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 TURF AREA PREPARATION

A. General: After finish grading of subgrade, loosen surface by tilling or raking.

B. Mix planting soil according to Section 32 91 13 "Soil Preparation."

C. Placing Planting Soil: Place and mix planting soil in place over exposed subgrade OR place manufactured planting soil over exposed subgrade.

D. Reduce elevation of planting soil to allow for soil thickness of sod.

E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph.

1. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
2. Do not use wet seed or seed that is moldy or otherwise damaged.
3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at a total rate of 3 to 4 lb/1000 sq. ft.

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with slopes exceeding 1:3with erosion-control blankets installed and stapled according to manufacturer's written instructions.

E. Protect seeded areas with slopes not exceeding 1:3 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas.

NOT FOR BIDDING PURPOSES

1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.

F. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch, and roll surface smooth.

3.5 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.
2. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.6 TURF MAINTENANCE

A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

NOT FOR BIDDING PURPOSES

C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings.

3.7 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.
2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.8 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

D. Remove nondegradable erosion-control measures after grass establishment period.

3.9 MAINTENANCE SERVICE

A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:

1. Seeded Turf: 60 days from date of planting completion or until all planting completion and initial acceptance, whichever is longer.

    a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

2. Sodded Turf: 30 days from date of planting completion or until all planting completion and initial acceptance, whichever is longer.

NOT FOR BIDDING PURPOSES

END OF SECTION

NOT FOR BIDDING PURPOSES

SECTION 32 93 00

PLANTING

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections "General Conditions of the Construction Contract", "Special Conditions" and "Division 1 – General Requirements" form a part of this Section by this reference thereto, and shall have the same force and effect as if printed herewith in full.

1.2 SUMMARY

A. Section includes:
   1. Deciduous and evergreen tree and shrub planting

B. Related sections include:
   1. Section 32 91 13 "Soil Preparation"
   2. Section 32 92 00 "Lawns"

1.3 SUBMITTALS

A. Submit a list of all nurseries that will supply plants.

B. Qualification Data: For qualified landscape Installer.

C. Soil Samples and Soil Test Reports: See 32 91 13 "Soil Preparation"

D. Plant Photographs: Submit color photographs of representative specimens of each type of tree on the plant list. Photos shall be 3"x5" taken from an angle that depicts the size and condition of the typical plant to be furnished. A scale rod or other measuring device shall be included in the photograph. Label each photograph with the plant name, size and name of growing nursery.

E. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of exterior plants during a calendar year. Submit before expiration of required maintenance periods.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Installer shall have not less than 5 years documented successful experience in meadow installations and be a member of the Landscape Contractors Association. Installer shall submit evidence of qualifications including photographs, locations and references of owners for review by the Landscape Architect and the Owners Representative.

NOT FOR BIDDING PURPOSES

B. Plant material observation: Landscape Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size and quality. Landscape Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.
   1. Notify Landscape Architect two weeks in advance of plant observation / tagging schedule.
   2. Notify Landscape Architect of sources of planting materials seven days in advance of delivery to site.

C. The contractor shall maintain continuously a competent supervisor, satisfactory to the Owner's Representative, with authority to act in all matter pertaining to this work.

D. Conference: Before any work is started a conference shall be held between the Contractor, the Owner's Representative and the Landscape Architect concerning the work under this contract.

E. Provide quality, size, genus, species, and variety of exterior plants indicated, complying with applicable requirements in ANSI Z60.1, "American Standard for Nursery Stock."

F. It is the Landscape Contractor's responsibility to coordinate and cooperate with the other Contractors to enable work to proceed rapidly and efficiently. Coordinate with all adjacent Contractors' work including all paving, lawn, electrical, etc.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver exterior plants freshly dug.

B. Do not prune trees and shrubs before delivery except as approved by Landscape Architect. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of exterior plants during delivery.

C. Deliver exterior plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set exterior plants and trees in shade, protect from weather and mechanical damage, and keep roots moist. Plants shall not be stored on site longer than 1 week.

1.6 PROJECT CONDITIONS

A. Plant material should be installed within the following dates: March 15 – June 1 or August 15 – October 15, or as approved by the Landscape Architect due to weather conditions. Plant material may not be dug after May 15.

B. Weather limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

NOT FOR BIDDING PURPOSES

1.7 MAINTENANCE SERVICE

A. Initial Planting Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until completion of building construction and initial acceptance of all plant material.

B. Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.8 ACCEPTANCE AND WARRANTY

A. An inspection of work completed shall be conducted by the Landscape Architect and Owner's Representative for the purpose of initial acceptance. Any outstanding items revealed on inspection and identified on the punch list shall be corrected with two weeks. Initial acceptance shall be withheld until those items are completed. Acceptance can be on partially completed work. Warranty, for a period of one year, shall begin after landscape inspection and initial acceptance.

B. Warrant in writing that all plant material, including groundcovers, placed on this Project will remain alive and be in healthy vigorous condition for a period of 1 year after completion and initial acceptance of entire project.

C. During the warranty period replace, in accordance with the drawings and specifications, all plants that are in an unhealthy or unsightly condition, or more than 25% dead. Warrant all replacement trees for an additional one year period.

D. Final Inspection and Acceptance: An inspection will be conducted with the Landscape Contractor, Landscape Architect and Owner at the end of the one year warranty period for purposes of Final Acceptance.

E. Warranty shall not include damage or loss of plants due to vandalism, fire, severe winds, extreme cold, or negligence on the Owner's part.

PART 2 - PRODUCTS

2.1 TREE MATERIAL

A. General: Furnish nursery-grown trees complying with ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

1. Root balls shall comply with ANSI 260.1 standards and shall meet sizes laid out in the ANSI 260.1 standards as well as being intact and undamaged when they arrive on the site. Trees that have deteriorated root balls will not be accepted.

B. If formal arrangements or consecutive order of trees shown, select stock for uniform height and spread, and number label to assure symmetry in planting.

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2.2 SHADE TREES

A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, complying with ANSI Z60.1 for type of trees required.

1. Provide balled and burlapped trees.
2. All trees shall have their north side marked in the nursery prior to digging. Set trees in the hole with the marker facing north.

2.3 EVERGREENS

A. Form and Size: Normal-quality, well-balanced, unsheared evergreens, of type, height, spread, and shape required.

2.4 TOPSOIL AND PLANT MIX: See Section 32 91 13 Soil Preparation

2.5 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight. Organic matter to be "Leaf Gro Compost" or approved equal.

2.6 FERTILIZER

A. Apply fertilizers only if recommended by soil testing.

B. All fertilizers shall be uniform in composition, free flowing and suitable for application with approved equipment. Applications shall be determined by soil test recommendations.

C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium.

D. Slow-Release Fertilizer: Granular or pellet fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium.

E. Planting tablets: Tightly compressed chip type, long lasting, slow release, commercial grade planting fertilizer in tablet form.

2.7 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of shredded hardwood. Natural color only.

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2.8 STAKES AND GUYS

A. Upright and Guy Stakes: Rough-sawn, sound, new hardwood or pressure-preservative-treated softwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch by length indicated, pointed at one end.

B. Guys and Tie Wires: No. 12 gauge galvanized wire.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, and lawns and existing exterior plants from damage caused by planting operations.

B. Lay out plants at locations directed by Landscape Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

3.2 TREE PIT EXCAVATION

A. Tree Pits: Excavate circular pits with sides sloped inward, as shown on the Drawings. Trim base leaving center area raised slightly to support root ball and assist in drainage. Do not further disturb base. Scarify sides of plant pit smeared or smoothed during excavation.
   1. Excavate approximately three times as wide as ball diameter.
   2. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
   3. Do not excavate subgrades of adjacent paving, structures, hardscapes or other new or existing improvements.

B. Subsoil and topsoil from excavations may be used as a component of the planting soil upon approval of the Landscape Architect.

C. Notify Landscape Architect if unexpected rock, obstructions or impermeable soils detrimental to trees or shrubs are encountered in excavations. Notify Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

3.3 TREE PLANTING

A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements. Do not use planting stock if root ball is cracked or broken before or during planting operation.

B. Set plants to the elevations shown on the drawings. Place a maximum 2” soil on top of root ball. Set trees on compacted pads as shown. Use plant mix specified to backfill pit approximately 2/3 full. Water thoroughly before installing remainder of the plant mix to top of pit, eliminating all air

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pockets. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.

C. Place planting tablets in each tree planting pit when pit is approximately one half filled, in amounts recommended in soils reports from soil testing laboratory. Place tablets beside the root ball about one inch from root tips.

D. Cut ropes and strings from top of tree root balls after plant has been set. Remove burlap or cloth wrapping from around top half of balls, do not remove from under root balls. Do not turn under and bury any portion of burlap.

E. Smooth planting areas to conform to the grades indicated after full settlement has occurred and mulch has been applied. Thoroughly water plants after mulching.

3.4 TREE PRUNING

A. Prune, thin, and shape trees as only as directed by Landscape Architect.

3.5 SHRUB PLANTING

A. Preparation of planting beds: Excavate entire planting bed to specified depths as shown on Drawings. Till subsurface to a depth of 6 inches. Place planting soil per specified depths, allowing for settlement.

B. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in shrub planting beds.

C. Mulch entire planting bed with mulch. Thoroughly water plants after mulching.

3.6 GUYING AND STAKING

A. Stake trees as shown on drawings.

3.7 CLEANUP AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.

B. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

3.8 MAINTENANCE

A. Contractor is responsible for the following maintenance period by pruning, cultivating, watering, weeding, fertilizing, restoring planting saucers, tightening and repairing stakes and guy supports,

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and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray as required to keep trees and shrubs free of insects and disease.

1. Maintenance Period: Until completion of building construction and initial acceptance of all plant material.

B. Maintenance between initial acceptance and final acceptance shall be the responsibility of the Owner.

END OF SECTION 32 93 00

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SECTION 33 05 05.36

VACUUM TESTING

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Vacuum testing of manholes.

1.2 SUBMITTALS

A. Submit the following items prior to start of testing:

1. Testing procedures.
2. List of test equipment.
3. Testing sequence schedule.
4. Provisions for disposal of flushing and test water.
5. Certification of test gage calibration.

B. Test and Evaluation Reports: Indicate results of manhole tests.

C. Qualifications Statement:

1. Qualifications for applicator.

1.3 QUALITY ASSURANCE

A. Perform Work according to Town of Smyrna standards.

B. Applicator: Company specializing in performing Work of this Section with three years' experience.

PART 2 - PRODUCTS

2.1 VACUUM TESTING

A. Equipment:

1. Vacuum pump.
2. Vacuum line.
3. Vacuum Tester Base:
   a. Compression band seal.
   b. Outlet port.

4. Shutoff valve.
5. Stopwatch.
6. Plugs.
7. Vacuum Gage: Calibrated to 0.1 in. Hg (0.34 kPa).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that manholes are ready for testing.

B. Verify that manholes are backfilled.

3.2 FIELD QUALITY CONTROL

A. Manhole Testing:

1. Repair both outside and inside of joint to ensure permanent seal.
2. Test manholes with manhole frame set in place.
3. Vacuum Testing:

    a. Comply with ASTM C1244 (C1244M).
    b. Plug pipe openings; securely brace plugs and pipe.
    c. Inflate compression band to create seal between vacuum base and structure.
    d. Connect vacuum pump to outlet port with valve open, then draw vacuum to 10 in. Hg.
    e. Close valve.
    f. Manhole Test Duration in Seconds:

        1) Manhole Diameter of 4 Feet: 90.
        2) Manhole Diameter of 5 Feet: 90.
        3) Manhole Diameter of 6 Feet: 90.

    g. Record vacuum drop during test period.
    h. If vacuum drop is greater than 1 in. Hg during testing period, repair and retest manhole.
    i. If vacuum drop of 1 in. Hg does not occur during test period, manhole is acceptable; discontinue testing.
    j. If vacuum test fails to meet 1 in. Hg drop in specified time after repair, repair and retest manhole.

4. If unsatisfactory testing results are achieved, repair manhole and retest until result meets criteria.
5. Repair visible leaks regardless of quantity of leakage.

END OF SECTION

NOT FOR BIDDING PURPOSES

SECTION 33 05 63

CONCRETE VAULTS AND CHAMBERS

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Precast concrete vaults and chambers.
2. Drainage system junction boxes.
3. Drainage system sedimentation chambers.
4. Knock-out boxes.
5. End walls.
6. Pipe ends.
7. Frames and covers.
8. Access hatches.

1.2 SUBMITTALS

A. Product Data: Manufacturer information regarding frames and covers, component construction, features, configuration, dimensions, and ladder.

B. Shop Drawings:

1. Vault or chamber locations, elevations, sections, equipment supports, piping, conduit, sizes and elevations of penetrations, and ladder.
2. Design, construction and installation details, typical reinforcement and additional reinforcement at openings and for each type, size, and configuration.

C. Concrete mix design for each different mix.

D. Manufacturer's Certificate: Products meet or exceed specified requirements.

E. Welder Certificates: Certify welders and welding procedures employed on Work, verifying AWS qualification within previous 12 months.

F. Delegated Design Submittals: Submit signed and sealed Shop Drawings with design calculations and assumptions for custom fabrications.

G. Manufacturer Instructions: Installation requirements, including storage and handling procedures.

H. Source Quality-Control Submittals: Indicate results of shop tests and inspections.

I. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

J. Qualifications Statements:

1. Qualifications for manufacturer, installer, and licensed professional.
2. Manufacturer's approval of installer.
3. Welders: Qualify procedures and personnel according to AWS D1.1/D1.1M.

1.3 QUALITY ASSURANCE

A. Obtain precast concrete vaults and chambers from single source.

B. Perform structural design according to ACI 318 (318M).

C. Perform Work according to NPCA Quality Control Manual for Precast and Prestressed Concrete Plants.

D. Material and Fabrication:

1. Single-Cell Box Culverts: Comply with ASTM C1433 (C1433M).
2. Three-Sided Structures: Comply with ASTM C1504 (C1504M).
3. Other Structures: Comply with ASTM C913.

E. Welding:

1. Structural Steel: Comply with AWS D1/1/D1.1M.
2. Reinforcing Steel: Comply with AWS D1.4/D1.4M.

F. Perform Work according to Town of Smyrna standards.

G. Manufacturer: Certified by NPCA Plant Certification Program prior to, and during Work of, this Section.

H. Installer: Company specializing in performing Work of this Section with three years' experience and approved by manufacturer.

I. Welders: AWS qualified within previous 12 months for employed weld types.

J. Licensed Professional: Professional engineer experienced in design of specified Work and licensed in State of Delaware.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Concrete Products: Do not deliver products until concrete has cured 7 days or has attained minimum 75 percent of specified 28-day compressive strength.

B. Storage:

1. Store materials according to manufacturer instructions.
2. Store vaults and chambers to prevent damage to Owner's property or other public or private property.

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3. Repair property damaged from materials storage.

C. Protection:

1. Protect materials in clean location remote from construction operations areas.
2. Provide additional protection according to manufacturer instructions.

1.5 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

1.6 WARRANTY

A. Furnish five-year manufacturer's warranty for concrete vaults, chambers, and appurtenances.

PART 2 - PRODUCTS

2.1 PERFORMANCE AND DESIGN CRITERIA

A. Minimum Loading: Comply with ASTM C857 and ASTM C890.

B. Roof Live Load, with Impact Loading:

1. Heavy Traffic:

a. Comply with AASHTO HB-17; HS20-44.
b. Maximum Each Wheel: 16,000 lbf.

2.2 PRECAST CONCRETE VAULTS AND CHAMBERS

A. Fabricator List:

1. Furnish materials according to Town of Smyrna standards.

B. Material of Construction: Reinforced precast concrete.

C. Foundation Slab:

1. Cast-in-place concrete of type as specified in Section 03 30 00 - Cast-in-Place Concrete.
2. Top Surface: Leveled.

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2.3 FRAMES AND COVERS

A. Manufacturers:
1. Furnish materials according to Town of Smyrna standards.

B. Description:

1. Materials of Construction:

a. Cast iron.
b. Comply with ASTM A48/A48M; Class 30B.

2. Lid:

a. Size: As indicated.
b. Surface: Machined flat bearing.
c. Type: Removable.
d. Security: Lockable.

3. Cover:

a. Design: Closed.
b. Fabrication: Molded.
c. Identification: Cast with municipality name.

4. Furnish sealing gasket.
5. Grate:

a. Configuration: Diagonal.
b. Size: As indicated.

2.4 ACCESS HATCHES

A. Manufacturers:

1. Furnish materials according to Town of Smyrna standards.

B. Description:

1. Materials of Construction: Aluminum; welded.
2. Size: As indicated.
3. Door Configuration: Double.
4. Cover:

a. Fabrication: Diamond plate.
b. Reinforce with structural stiffeners as required to support indicated loads.

5. Frame:

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a. Type: Channel.
b. Furnish integral seat to support cover stiffeners.
c. Anchor flange around frame perimeter.

6. Hinge Material: Stainless steel.
7. Lift Handle:

a. Type: Flush drop; non-removable.
b. Mounting: In cover.

8. Lifting Mechanism:

a. Compression Springs: Stainless steel.
b. Furnish automatic hold-open and dead stop to retain cover in open position.
c. Cover springs to prevent contact by personnel entering vault or chamber.

9. Latch Mechanism:

a. Lock: Stainless steel.
b. Furnish removable external handle and permanent internal release mechanism.

10. Hardware: Stainless steel.
11. Finishes: Galvanized after fabrication.

2.5 MATERIALS

A. Concrete:

1. Portland Cement:

a. Comply with ASTM C150/C150M.
b. Type: II.

2. Fine and Coarse Aggregates: Comply with ASTM C33/C33M, except that gradation requirements do not apply.

B. Admixtures:

1. Furnish materials according to Town of Smyrna standards.
2. Air Entrainment: Comply with ASTM C260/C260M.
3. Chemical Admixtures:

a. Comply with ASHTO M194.

4. Fly Ash: Comply with DelDOT specifications.
5. Blast Furnace Slag: Comply with DelDOT specifications.

C. Concrete Reinforcement:

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1. Reinforcing Steel:

    a. Comply with DelDOT specifications.

2. Reinforcing Wire:

    a. Plain Wire:

        1) Comply with DelDOT specifications.
        2) Finish: Comply with DelDOT specifications.

    b. Deformed Wire:

        1) Comply with DelDOT specifications.
        2) Finish: Comply with DelDOT specifications.

3. Welded Steel Wire Fabric:

    a. Plain Wire:

        1) Plain Wire: Comply with DelDOT specifications.
        2) Finish: Comply with DelDOT specifications.

    b. Deformed Wire:

        1) Comply with DelDOT specifications.
        2) Finish: Comply with DelDOT specifications.

2.6 FABRICATION

A. Comply with ACI 318 (318M) and NPCA Quality Control Manual for Precast and Prestressed Concrete Plants.

B. Fabricate vaults, chambers, and openings to size and configuration as indicated.

C. Forms:

1. Fabricate to provide uniform precast concrete units with consistent dimensions.
2. Clean after each use.

D. Reinforcing:

1. Install reinforcement by tying or welding to make rigid assemblies.
2. Position reinforcement to maintain minimum 2-inch cover.
3. Secure reinforcement to prevent displacement while placing concrete.

E. Position and secure embedded items to prevent displacement while placing concrete.

F. Deposit concrete in forms and consolidate concrete without segregating aggregate.

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G. Provide initial curing by retaining moisture using one of following methods:

1. Cover with PE sheets.
2. Cover with burlap or other absorptive material and keep continually moist.
3. Apply curing compound according to manufacturer instructions.

H. Provide final curing according to manufacturer's standard.

I. Remove forms without damaging concrete.

2.7 MIXES

A. Concrete:

1. Normal Weight: Select proportions according to ACI 2111.1 and 318 (318M).
2. Concrete Criteria:

a. Compressive Strength: 4,000 psi at 28 days.
b. Water-Cement Ratio:
1) Per DelDOT specifications.

c. Air Content:

1) Per DelDOT specifications

3. Admixtures:

a. Provide admixture types and quantities indicated in concrete mix designs approved through submittal process.
b. Do not use calcium chloride.

2.8 FINISHES

A. Reinforcing Steel:

1. Galvanized Finish: Comply with ASTM A767/A767M, Class [I] [II].
2. Epoxy-Coated Finish: Comply with ASTM A775/A775M.

B. Wire and Wire Fabric:

1. Epoxy-Coated Finish: Comply with ASTM A884/A884M, Class A.

C. Concrete:

1. Formed Surfaces Not Exposed to View: As formed.
2. Unformed Surfaces:

a. Finish with vibrating screed or hand float.
b. Items Permitted: Color variations, minor indentations, chips, and spalls.

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c. Items Not Permitted: Major imperfections, honeycomb, or other such defects.

3. Exposed-to-View Finishes:

a. Surfaces: Light broom.

D. Steel:

1. Galvanizing:

a. Comply with ASTM A123/A123M.
b. Hot-dip galvanize after fabrication.

2.9 ACCESSORIES

A. Membrane Curing Compound: Per DelDOT Standards.

B. Step Rungs:

1. Material: Formed steel-reinforced PP.
2. Diameter: 0.5 inch.
3. Width: 12 inches.
4. Spacing: 8 inches o.c. vertically [As indicated].

C. Inserted and Embedded Items:

1. Structural-Steel Sections:

a. Comply with ASTM A36/A36M.
b. Finish: Galvanized.

D. Joint Sealants and Joint Gaskets:

1. Gasket Joints for Circular Concrete Pipe:

a. Comply with ASTM C443 (C443M).
b. Gaskets: Oil-resistant rubber.

2. External Sealing Bands:

a. Comply with ASTM C877 (C877M).
b. Material: Type II.

3. Preformed Joint Sealants for Concrete Pipe and Box Sections: Comply with ASTM C990 (C990M).
4. Elastomeric Joint Sealants:

a. Comply with ASTM C920.
b. Material: Silicone.
c. Grade NS, Class 25.

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d. Sikaflex, as manufactured by Sika.

E. Pipe Entry Connectors: Comply with ASTM C923 (C923M).

F. Grout:

1. Cement Type: Portland cement, sand, and water mixture with stiff consistency to suit intended purpose.
2. Nonshrink Type:

a. Description: Premixed compound consisting of nonmetallic aggregate, cement, and water-reducing and plasticizing agents.
b. Comply with ASTM C1107/C1107M.
c. Minimum Compressive Strength: 3500 psi in 24 hours, and 14,000 psi in 28 days.
d. Precision Non-Shrink Grout as manufactured by Quikcrete.

G. Bituminous Coating:

1. Manufacturers:
a. Furnish materials according to Town of Smyrna standards.

H. Touch-Up Primer for Galvanized Surfaces:

1. SSPC Paint 20, Type II Organic.
2. Comply with ASTM A780/A780M.

2.10 SOURCE QUALITY CONTROL

A. Testing:

1. Perform following tests for each 9 cu. yd. of concrete placed with minimum one set of tests each week:

a. Slump: Comply with ASTM C143/C143M.
b. Compressive Strength: AASHTO T22.
c. Air Content: Comply with AASHTO T152 modified to AASHTO T196.
d. Unit Weight: Comply with AASHTO T121.

2. Make test results available to Architect/Engineer and Owner upon request.

B. Inspection:

1. Visually inspect completed vaults and chambers for defects.
2. Repair defects on surfaces exposed to view to achieve uniform appearance.
3. Repair honeycomb by removing loose material and applying grout to produce smooth surface flush with adjacent surface.
4. Repair major defects only if permitted by Architect/Engineer and Owner.

C. Certificate of Compliance:

NOT FOR BIDDING PURPOSES

1. If manufacturer is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at manufacturer's facility conforms to Contract Documents.
2. Specified shop tests are not required for Work performed by approved manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that items provided by other Sections of Work are properly sized and located.

B. Verify correct size and elevation of excavation.

C. Verify that subgrade and bedding are properly prepared, compacted, and ready to receive Work of this Section.

3.2 PREPARATION

A. Mark each vault or chamber by indentation or using waterproof paint showing date of manufacture, manufacturer, and identifying symbols and numbers to indicate its intended use.

B. Coordinate placement of inlet and outlet pipe or duct sleeves required by other Sections.

C. Do not install vault or chamber if Site conditions induce loads exceeding weight capacity of vault or chamber.

D. Inspect vaults and chambers immediately prior to placement in excavation to verify that they are internally clean and free from damage; remove and replace damaged units.

3.3 INSTALLATION

A. According to ASTM C891.

B. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface structures or utilities in immediate or adjacent areas.

C. While lowering vaults or chambers into excavations and joining pipe to units, take precautions to ensure that interiors of pipeline and structure remain clean.

D. Install vaults and chambers to elevation and alignment as indicated.

E. Excavating:

1. As specified in Section 31 23 16 - Excavation and in indicated locations and depths.
2. Provide clearance around sidewalls of manhole or structure for construction operations, granular backfill.

NOT FOR BIDDING PURPOSES

3. If ground water is encountered, prevent accumulation of water in excavations; place manhole or structure in dry trench.
4. Remove large stones or other hard matter impeding consistent backfilling or compaction.
5. Where possibility exists of watertight manhole or structure becoming buoyant in flooded excavation, anchor manhole or structure to avoid flotation as approved by Architect/Engineer.
6. Correct over-excavation with coarse aggregate.

F. Base and Alignment:

1. Install vaults and chambers supported at proper grade and alignment on compacted crushed-stone bedding.
2. Grout base of shaft to achieve slope to drain, trowel smooth, and contoured as indicated.

G. Assembly of Multisection Structures:

1. Lower each section into excavation.
2. Clean joint surfaces.
3. Install watertight joint seals according to manufacturer instructions using preformed joint sealants.

H. Knock-out Boxes:

1. Remove knock outs or cut structure to receive piping without creating openings larger than required to fit pipe.
2. Fill annular space with grout.

I. Connections:

1. Connect pipe to structure and seal watertight.
2. Cut pipe flush with interior of structure.

J. Paint interior with two coats of bituminous interior coating at rate of 200 sq. ft./gal. for each coat.

K. Frame and Cover and Access Hatch:

1. Set level, without tipping, to elevations as indicated.
2. Set cover and access hatch 0 inches above finished grade for structures located within unpaved areas to allow area to be graded away from cover beginning 3 inches below top surface of frame.
3. Connect drain from access hatch frame to storm drainage system.
4. Touch up damaged galvanized coatings.

L. Installation Standards: Install Work according to Town of Smyrna standards.

3.4 FIELD QUALITY CONTROL

A. Testing:

NOT FOR BIDDING PURPOSES

1. As specified in Section 33 05 05.36 - Vacuum Testing.

END OF SECTION

NOT FOR BIDDING PURPOSES

SECTION 33 10 00

WATER UTILITIES

PART 1 - GENERAL

1.01 SUMMARY

A. Provide an operating underground, exterior water service piping system. Include piping, control valves, and steel and concrete anchorages. Include water service system and piping, accessories, and appurtenances for potable water and fire service outside the building.

1.02 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Shop Drawings: Submit shop drawings indicating material characteristics, details of construction, connections, and relationship with adjacent construction.

1.03 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

B. Testing: Hydrostatic tests at minimum 1-1/2 times working pressure for 2 hours.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Ductile Iron Pipe 4 Inches and Larger: AWWA C151, Class 50 minimum.

1. Lining: AWWA C104, cement mortar, seal coated.
2. Gaskets: AWWA C111.
3. Ductile Iron and Cast-Iron Fittings, AWWA C110 or AWWA C153, 250 psi minimum pressure rating; AWWA C104 cement mortar lining; AWWA C111 rubber gaskets.

B. PVC Pipe 4 Inches and Larger: AWWA C900, Class 150.

1. Gaskets: ASTM F 477, elastomeric seal.
2. PVC Couplings and Fittings: AWWA C900 with ASTM F 477 elastomeric seal gaskets.
3. Ductile Iron and Cast-Iron Fittings: AWWA C110, 250 psi pressure rating; AWWA C104 cement mortar lining; AWWA C111 rubber gaskets.

C. Fiberglass Pressure Pipe 2 Inches and Larger: AWWA C950, Type I filament wound or Type II centrifugally cast; Grade 1 or 2; fiberglass fittings, AWWA C950, RTRP, 200 psi minimum pressure rating.

D. Copper Water Tube 2 Inches and Smaller: ASTM B 88, Type K seamless, annealed temper; ANSI B16.22 wrought-copper solder-joint copper fittings.

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E. Copper Water Tube 2 Inches and Smaller: ASTM B 88, Type L seamless, annealed temper; ANSI B16.22 wrought-copper solder-joint copper fittings.

F. PVC Pipe 3 Inches and Smaller: ASTM D 1785, Schedule 40; Schedule 40 socket-type PVC fittings or elastomeric gasketed joint.

G. Polybutylene Pipe 3 Inches and Smaller: AWWA C902, DR 17 barbed insert type brass or bronze fittings.

H. Polybutylene Pipe 3 Inches and Smaller: ASTM D 2662, SIDR15 barbed insert type brass or bronze fittings.

I. Polybutylene Tubing 3 Inches and Smaller: ASTM D 2666, SIDR13.5 brass or bronze fittings.

J. Polyethylene Pipe and Tubing 3 Inches and Smaller: AWWA C901; barbed insert type copper alloy or nylon fittings.

K. Couplings: ASTM A 126, gray iron sleeve assembly with followers, rubber gaskets, bolts, nuts, and enamel paint finish.

L. Valves:

1. Nonrising stem gate valves 3 Inches and larger, AWWA C500.
2. Rising stem gate valves 3 Inches and larger, AWWA C500 or AWWA C509.
3. Nonrising stem gate valves 2 inches and smaller, MSS SP-80.
4. Valve Accessories: Cast-iron valve boxes, curb stops, and service boxes for curb stops.
5. Tapping sleeve and tapping valve for new connections larger than 2 inches.
6. Service clamps and corporation stops for new connections 2 inches and smaller.

M. Anchorages:

1. Clamps, Straps, and Washers: ASTM A 506, steel.
2. Rods: ASTM A 575, steel.
3. Rod Couplings: ASTM A 197, malleable iron.
4. Bolts: ASTM A 307, steel.
5. Cast-Iron Washers: ASTM A 126, gray iron.
6. Concrete Reaction Backing: ASTM C 150, Type I Portland cement for 3000 psi, 28 day minimum compressive strength.

N. Yard Hydrants: Post type.

O. Valve Pits and Meter Pits: Reinforced concrete with ladder and cast-iron manhole frame and cover.

P. Water Meter: Utility company water meter.

Q. Meter Box: Cast-iron body and cover with lettering.

R. Identification: Metallic-lined plastic underground warning tapes.

S. Fire Service Main Accessories:

1. Hose House: 16-gauge (.0598 inches) steel with red baked enamel finish, hoses, and nozzles.

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2. Alarm Devices: UL 753 and FM approved including water flow indicators, supervisory switches, and pressure switches.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install materials and systems in accordance with manufacturer's instructions and approved submittals. Install materials and systems in proper relation with adjacent construction. Coordinate with work of other sections.

B. Clean and disinfect system. Test for proper operation. Backfill and protect work from damage.

END OF SECTION

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SECTION 33 31 11

PUBLIC SANITARY SEWERAGE GRAVITY PIPING

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sanitary sewerage piping.
2. Connection to existing manholes.
3. Wye branches and tees.
4. Sanitary laterals.
5. Pile support systems.
6. Bedding and cover materials.

1.2 DEFINITIONS

A. ABS: Acrylonitrile butadiene styrene.

B. Bedding: Fill placed under, besides, and directly over pipe, prior to subsequent backfill operations.

C. EPDM: Ethylene-propylene-diene terpolymer.

1.3 SUBMITTALS

A. Product Data: Manufacturer catalog cuts and other information indicating proposed materials, accessories, details, and construction information.

B. Manufacturer's Certificate: Products meet or exceed specified requirements.

C. Test and Evaluation Reports: Indicate field tests made and results obtained.

D. Manufacturer Instructions:

1. Special procedures required to install specified products.

E. Source Quality-Control Submittals: Indicate results of factory tests and inspections.

F. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

G. Qualifications Statement:

1. Qualifications for manufacturer and installer.

1.4 SUSTAINABLE DESIGN SUBMITTALS

A. Manufacturer's Certificate: Products meet or exceed specified sustainable design requirements.

B. Materials Resources Certificates:

1. Source and origin for salvaged and reused products.
2. Recycled material content for recycled content products.
3. Source for regional materials and distance from Project Site.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record invert elevations and actual locations of pipe runs, connections, manholes, and cleanouts.

B. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.6 QUALITY ASSURANCE

A. Perform Work according to Town of Smyrna standards.

B. Manufacturer: Company specializing in manufacturing products specified in this Section with three years' experience.

C. Installer: Company specializing in performing the Work of this Section with three years' experience and approved by manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Storage:

1. Store materials according to manufacturer instructions.
2. Store valves in shipping containers with labeling in place.

B. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Block individual and stockpiled pipe lengths to prevent moving.
3. Provide additional protection according to manufacturer instructions.

1.8 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.

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2. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 SANITARY SEWERAGE PIPING

A. Ductile-Iron Pipe:

1. Comply with AWWA C151.
2. Minimum Pressure Class: 50.
3. End Connections: Bell and spigot.
4. Outside Coating:

a. Type: Asphaltic; comply with AWWA C151.
b. Minimum Uniform Thickness: 1.

5. Lining: Cement mortar; comply with AWWA C104.

6. PE Encasement: Comply with AWWA C105.

7. Fittings:

a. Material: Ductile iron, Class 350 PS or greater.
b. Comply with AWWA C153.
c. Lining: Cement-mortar lined; AWWA C104.

8. Coating:

a. Coat pipe and fittings exposed inside of structures with two coats of Sherwin Williams bituminous paint to achieve minimum dry film thickness of 3 mils per coat.
b. As specified in Section 09 90 00 - Painting and Coating.

9. Joints: Mechanical.

B. Plastic Pipe:

1. Material: PVC.
2. Comply with ASTM D3034, SDR- 26.
3. Inside Nominal Diameter: As shown on plans.
4. End Connections: Bell-and-spigot style, with rubber-ring-sealed gasket joint.
5. Fittings: PVC.
6. Joints: Elastomeric gaskets; comply with ASTM F477.

2.2 MANHOLES

A. As specified in Section 33 05 61 - Concrete Manholes.

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2.3 FLEXIBLE COUPLINGS

A. Manufacturers:

1. Fernco Inc.
2. Romac Industries, Inc.
3. Substitutions: Permitted.

B. Description:

1. Material: Resilient, chemical-resistant, elastomeric PVC.
2. Attachment: Two Series-300 stainless-steel clamps, screws, and housings.

2.4 FLEXIBLE PIPE BOOTS FOR MANHOLE PIPE ENTRANCES

1. Furnish materials according to Town of Smyrna standards.

B. Description:

1. Material: EPDM.
2. Comply with ASTM C923 (C923M).
3. Attachment: Series-300 stainless-steel clamp and hardware.

2.5 CONCRETE ENCASEMENT AND CRADLES

A. Concrete:

1. As specified in Section 03 30 00 - Cast-in-Place Concrete.
2. Strength: 4,000 psi at 28 days.
3. Air entrained.
4. Finish: Rough troweled.

2.6 MATERIALS

A. Bedding and Cover:

1. Bedding: Fill Type A3, as specified in Section 31 05 16 - Aggregates for Earthwork.
2. Cover: Fill Type A3, as specified in Section 31 05 16 - Aggregates for Earthwork.
3. Soil Backfill from Above Pipe to Finish Grade:

   a. Soil Type 52, as specified in Section 31 05 13 - Soils for Earthwork.
   b. Subsoil with no rocks more than 0.5 inches in diameter, frozen earth, or foreign matter.

2.7 FINISHES

A. Galvanizing:

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1. Hot-dip galvanize after fabrication.
2. Comply with ASTM A123/A123M.

2.8 ACCESSORIES

A. Pile Support Brackets: Galvanized structural steel, thoroughly coated with bituminous paint.

B. Pipe Markers: As specified in Section 33 05 97 - Identification and Signage for Utilities.

2.9 SOURCE QUALITY CONTROL

A. Provide shop inspection and testing of pipe.

B. Certificate of Compliance:

1. If manufacturer is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at manufacturer's facility conforms to Contract Documents.
2. Specified shop tests are not required for Work performed by approved manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that trench cut is ready to receive Work of this Section.

B. Verify that excavations, dimensions, and elevations are as indicated.

3.2 PREPARATION

A. Correct over-excavation with coarse aggregate.

B. Remove large stones or other hard materials that could damage pipe or impede consistent backfilling or compaction.

C. Protect and support existing sewer lines, utilities, and appurtenances.

D. Utilities:

1. Maintain profiles of utilities.
2. Coordinate with other utilities to eliminate interference.
3. Notify Architect/Engineer if crossing conflicts occur.

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3.3 INSTALLATION

A. Bedding:

1. Excavate pipe trench as specified in Section 31 23 16.13 - Trenching.
2. Excavate to lines and grades as indicated, or as required to accommodate installation of encasement.
3. Dewater excavations to maintain dry conditions and to preserve final grades at bottom of excavation.
4. Provide sheeting and shoring as specified in Section 31 23 16.13 - Trenching.
5. Placement:
    a. Place bedding material at trench bottom.
    b. Level materials in continuous layer not exceeding 8-inch compacted depth.
    c. Compact to 95 percent of maximum density.

B. Piping:

1. Install pipe, fittings, and accessories according to ASTM D2321, and seal joints watertight.
2. Lay pipe to slope gradients as indicated.
3. Bedding: As indicated.
4. Lay bell-and-spigot pipe with bells upstream.
5. PE Pipe Encasement: Comply with AWWA C105.
6. Backfill and compact as specified in Section 31 23 16.13 - Trenching.
7. Connect pipe to at existing manhole.
8. Pipe Markers: As specified in Section 33 05 97 - Identification and Signage for Utilities.
9. Installation Standards: Install Work according to Town of Smyrna standards.

C. Manholes: As specified in Section 33 05 61 - Concrete Manholes.

D. Connections to Existing Manholes:

1. Drilling:
    a. Core drill existing manhole to clean opening.
    b. Use of pneumatic hammers, chipping guns, sledge hammers are not permitted.
2. Install watertight neoprene gasket and seal with nonshrink concrete grout.
3. Prevent construction debris from entering existing sewer line when making connection.

E. Wye Branches and Tees:

1. Concurrent with pipe-laying operations, install wye branches and pipe tees at locations as indicated.
2. Use standard fittings of same material and joint type as sewer main.
3. Maintain minimum 3-foot separation distance between wye connection and manhole.
4. Use saddle wye or tee with stainless-steel clamps for taps into existing piping.

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5. Mount saddles with solvent cement or gasket and secure with metal bands.
6. Lay out holes with template, and cut holes with mechanical cutter.

F. Sanitary Laterals:

1. Construct laterals from wye branch to terminal point at right-of-way.
2. Where depth of main pipeline warrants, construct riser-type laterals from wye branch.
3. Minimum Depth of Cover over Piping: 4 feet.
4. Minimum Separation Distance between Laterals: 5 feet.
5. Install watertight plug, braced to withstand pipeline test pressure thrust, at termination of lateral.
6. Marker Stake:

a. Install temporary marker stake extending from end of lateral to 12 inches above finished grade.
b. Paint top 6 inches of stake with fluorescent orange paint.

G. Backfilling: As specified in Section 31 23 23 - Fill.

3.4 FIELD QUALITY CONTROL

A. Request inspection by Architect/Engineer prior to and immediately after placing bedding.

B. Testing:

1. If tests indicate that Work does not meet specified requirements, remove Work, replace, and retest.
2. Perform testing on Site sanitary sewage system according to Town of Smyrna standards.

3. Compaction Testing:

a. Comply with ASTM D1557.
b. Testing Frequency: As requested.

3.5 PROTECTION

A. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.

B. Cap open ends of piping during periods of Work stoppage.

END OF SECTION

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SECTION 33 40 00

STORM DRAINAGE UTILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section covers storm drain pipe and appurtenances.

B. The Contractor shall furnish all labor, materials, and appurtenances necessary to complete all storm drain construction shown on the drawings.

PART 2 - PRODUCTS

2.1 REINFORCED CONCRETE PIPE

A. Reinforced concrete materials used for precast pipe shall conform to Section 32 11 36, "Concrete Base Courses" and shall have a minimum compressive strength of 4000 psi after 28 days of placement.

B. Reinforced concrete pipe shall be manufactured without lifting holes and shall be handled at all times by means of slings or other methods approved prior to start of construction.

C. Reinforced concrete pipe shall meet the applicable strength requirements contained in ASTM Designation: C-76, Reinforced Concrete Culvert, Storm Drain and Sewer Pipe, minimum circumferential reinforcement shall be as prescribed for Class IV.

2.2 MASONRY MATERIALS

A. Mortar for pipe joints and connections to other drainage structures shall be composed of 1 part by volume Portland cement and 2 parts sand. Portland cement shall conform to ASTM C150. Sand shall conform to ASTM C144. Hydrated lime may be added to the mixture of mortar in an amount of not more than 20 percent of the volume of cement. Hydrated lime shall conform to ASTM C141.

2.3 CONCRETE PIPE JOINTS

A. Concrete pipe joints shall be cement mortar bell-and-spigot-joints. The first pipe shall be bedded to the established gradeline, with the bell end placed upstream. The interior surface of the bell shall be cleaned with a wet brush and the lower portion of the bell filled with mortar to such a depth as to bring the inner surfaces of the abutting pipes flush and even. The spigot end of each subsequent pipe shall be cleaned and uniformly matched into the bell so the sections are closely fitted. After each section is laid, the remainder of the joint shall be filled with mortar and a bead formed around the outside of the joint with additional mortar. The cement mortar, finish, and protection of joints shall be as specified. If the mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint shall be wrapped with cheesecloth to hold the mortar in place.

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2.4 BACKFILL MATERIALS

A. Backfill materials shall conform to Section 31 2300, "Excavation for Pipelines and Structures".

2.5 CASTINGS

A. Frames and covers for junction box shall be set by the Contractor as the work progresses. The frame shall be well bedded in mortar.

B. Materials for frames and covers shall be in accordance with the standard specifications for gray iron castings ASTM Designation A-48 for Class No. 35.

C. All frames and covers shall be of the sizes and types detailed on the plans.

D. Inlet gratings shall conform with the detail shown on the plans and/or for the Delaware Department of Highways and Transportation Standard Specifications and Standard Details.

PART 3 - EXECUTION

3.1 EXCAVATION AND BACKFILL

A. Excavation and backfill shall be in accordance with Section 31 2300, "Excavation for Pipelines and Structures."

3.2 MATERIAL STORAGE

A. Materials required in the work shall be located and retained a sufficient distance from the edge of excavations to prevent such material falling or sliding into the excavations and to prevent cave-ins.

3.3 PIPE INSTALLATION

A. Installation of pipe materials shall conform to the written or published instructions of the manufacturer, except as otherwise specified. The manufacturer's written or published instructions shall supersede referenced national association or trade standard installation practices such as ASTM C12, for the specified material. Where the Contractor proposes to deviate from specified instructions, the proposed deviation shall be submitted for approval.

B. Under no circumstances shall pipe be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Laid pipe shall be inspected before backfilling is initiated.

C. Pipe shall be visually inspected for apparent defects and tapped with a hammer to audibly detect hidden defects, prior to being lowered into a trench.

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D. Defective materials found shall be distinctly marked using a road-traffic-quality yellow paint and promptly removed from the site.

E. Pipe shall be laid beginning at a low point of a system and, when in final acceptance position, shall be true to the grades and alignment indicated, with unbroken continuity of invert.

F. Type RCP shall be installed in accordance with the applicable recommendations of ACPA, "Concrete Pipe Installation Manual," except as otherwise specified.

G. Pipe and fittings shall be clean and dry when laid.

H. Pipe, when ready for specified acceptance testing, shall be "broom clean."

I. Interior of line shall be cleared of dirt and superfluous matter as the work progresses. A swab or drag shall be kept in the line and pulled forward past each joint immediately upon completion of the joint. In lines where man entry is possible, brushes and brooms may be used for cleaning. Plugs shall be placed in the ends of uncompleted work at the end of the day and whenever work stops. Plugs shall be commercially manufactured products, unless otherwise approved.

J. Pipe shall be checked to determine whether line displacement or other defects have occurred. Inspection shall take place when 2 feet of earth cover is in place and upon completion of project. A flashlight or mirror-reflected sunlight shall be flashed between manholes. If the illuminated interior indicates poor alignment, debris, displaced pipe infiltration, or other defects, the defects designated shall be remedied by the Contractor.

3.4 BACKFILLING

Backfilling shall conform to Section 31 23 00, "Excavation and Backfill for Pipelines and Structures."

3.5 GRADING

Grading shall conform to Section 31 00 00, "Earthwork".

3.6 DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Excess excavated material, trash, debris, and waste materials shall be removed from the project site and legally disposed at no additional cost to the Owner. Permits and fees for disposal shall be paid by the Contractor.

END OF SECTION

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SECTION 33 46 11

STORMWATER PONDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This work consists of constructing stormwater management facilities.

B. Section Includes:

1. Excavating and filling for rough grading the Site.
2. Preparing subgrades for stormwater management.
3. Excavating and backfilling trenches for utilities and pits for buried utility structures.
4. Dewatering.

C. Related Requirements:

1. Section 33 40 00 "Storm Drainage Piping".

1.3 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

C. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

D. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.

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2. Bulk Excavation: Excavation more than 10 feet (3 m) in width and more than 30 feet (9 m) in length.
3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.

E. Fill: Soil materials used to raise existing grades.

F. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

G. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

1.4 SUBMITTALS

A. Product Data: For each type of the following manufactured products required:

1. Geotextiles.
2. Source of materials.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:

1. Classification according to ASTM D 2487.
2. Laboratory compaction curve according to ASTM D 698 or ASTM D 1557.

1.6 FIELD CONDITIONS

A. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.

1. Do not proceed with work on adjoining property until directed by Architect.

B. Utility Locator Service: Notify "Miss Utility**"** for area where Project is located before beginning earth-moving operations. Contract with private utility company and verify utilities.

C. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified in Section 01 50 00 "Temporary Facilities and Controls" are in place.

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PART 2 - PRODUCTS

2.1 MATERIALS

A. References to sections used in Part 2 and Part 3, of this specification section apply to DelDOT Standard Specifications unless otherwise noted.

B. Provide material as specified below and in accordance with what is shown in the plans.

C. Infiltration Stone (No. 3, No. 8, or No. 57). Place infiltration stone meeting the following requirements:

1. Stone: Use stone that meets the material and gradation requirements of respective Section 1004 of the DelDOT Standard Specifications. Use infiltration stone that is washed, free of stone dust, fines or soil particles and has a maximum of 2.0 percent passing the #200 sieve when tested according to AASHTO T11. Do not use crushed concrete or recycled asphalt pavement (RAP) for this purpose.
2. Use geotextile fabric meeting the requirements in Section 1060 of DelDOT's Standard Specifications.

D. Clay Borrow. Use clay borrow that conforms to the following requirements:

1. Cut-Off Trench: Use clay borrow that conforms to Section 1002.01, Clay Borrow, Type 2.
2. Pond Liner: Use clay borrow that conforms to Section 1002.01, Clay Borrow, Type 1.
3. Borrow Sources: Comply with the requirements of Section 209.03.1.
4. Borrow Source Testing: Comply with the requirements of Section 209.03.2.

E. Outlet Structure, Concrete. Construct concrete outlet structures that meet the following requirements.

1. Borrow: Provide material as specified in Section 209 and Section 1001.
2. Concrete: Concrete used in riser structures may be precast or cast-in-place. Use only cast-in-place concrete for walls, anti-seep collars, and bedding for a principal spillway. Use Class A concrete for foundations, riser structures, walls, anti-seep collars, and bedding for a principal spillway pipe. Use Class A concrete meeting the requirements of Section 1022.
3. Reinforcing Steel: Use Grade 60 reinforcing steel meeting the requirements of Section 1037.
4. Grout: Use non-shrink grout conforming to the requirements of Section 1047.02.
5. Pipe: Refer to Section 1031 of DelDOT's Standard Specifications for the reinforced concrete pipe when used as a principal spillway.
6. Gaskets: Refer to Section 1031 of DelDOT's Standard Specifications for gaskets to be used with reinforced concrete pipe.
7. Steps: When steps are required, use molded plastic steps with a reinforcing bar core conforming to the requirements of AASHTO M31, ASTM C478, and ASTM D4101.
8. Trash Rack: All trash racks supplied for outlet structures will be aluminum, unless stated otherwise on the plans.

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F. Stormwater Management Pond.

1. If the basin will have a pond liner and/or a cut-off trench, provide material that meets the requirements of Section 910.02B of the DelDOT Standard Specifications. All other material will meet the requirements of Section 209, Section 908, and Section 1001.

PART 3 - EXECUTION

3.1 CONSTRUCTION

A. Before construction starts on my stormwater management facility during any phase of production, the Stormwater Engineer or delegated representative will be contacted a minimum of two working days in advance.

B. Outlet Structure, Concrete: Construct as in accordance with Section 610 of DelDOT's Standard Specification and the following:

1. Excavation: Excavate for the outlet structure to the required depth. Compact the foundation upon which the structure is to be placed to a firm, level, and unyielding surface. If dewatering is needed, than follow the requirements of Section 902 and Section 906.
2. Riser: To construct concrete riser, pour the concrete in place or use pre-cast concrete elements. If the concrete risers are pre-cast, design the lifting lugs, and all hardware required to transport and install the structure. Do not use the top slab to lift the riser structure. Fill any space between pipes and the walls of the pre-cast riser with non-shrink grout. The largest dimension of the opening in the riser of connection of the outfall pipe shall be no greater than the outfall pipe diameter plus 4 inches.
3. Anti-Seep Collars: To construct anti-seep collars, excavate the subgrade to the dimensions of the bottom half of the collars. Use the excavation as the form for the bottom half of the anti-seep collars. Place formwork for the top half of the anti-seep collars.
4. Principal Spillway Outfall Pipe: Construct as in accordance with Section 601 and the following:
    a. Use Class A concrete meeting the requirements of Section 1022 and place as shown per the Standard Construction Detail, Pipe Bedding. Use concrete shims to establish grade and alignment of the pipe. Do not use lumber, masonry bricks, or any other non-concrete material for shims. Exercise care during backfill to prevent any pipe movement from the proposed horizontal and vertical alignment. The length of Class A pipe bedding to be installed will be specified on the plans.
    b. When the principal spillway outfall pipe is to be placed partially or completely in fill, construct the fill embankment 24 inches above the proposed top of pipe, then excavate the trench to the required grade.

C. Stormwater Management Pond: Use the following construction methods to construct a stormwater management pond.

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1. Foundation and Reservoir Preparation: Prior to constructing the dam foundation and reservoir, clear and grub the area of trees, logs, stumps, roots, brush, boulders, sod, topsoil, and rubbish. Grade all surfaces under the foundation to remove irregularities.
2. Outlet structure placement: Construct outlet structure in accordance with 910.03.A and as noted on the plans.
3. Excavation:
   a. Wet Stormwater Management Pond: Excavate to the lines and grades shown on the plans or as directed by the Engineer with concurrence from the Stormwater Engineer.
4. Foundation, Embankment, and Slope Construction: Foundation, embankment, and slope construction will be completed as in accordance with Section 202, except for an infiltration basin bottom elevation. Use all suitable excavated material to construct the foundation and embankment. If permitted by the Engineer, materials determined to be unsuitable for use in the dam foundation and embankment may be deposited on slopes. Otherwise, use all excess material meeting the requirements for embankment to construction embankments as required by the contract documents. Remove all material in excess of the project's embankment requirements and all material that is unsuitable for embankment. If rock is encountered, excavate per Section 202.
   a. Cut-Off Trench: If needed, key the foundation cut-off trench into original ground as shown on the plans. Excavate the foundation cut-off trench prior to placing the dam embankment. The trench shall have a minimum 4 foot bottom width. The side slopes of the cut-off trench shall be no steeper than 1:1. As the embankment construction progresses, so will the cut-off trench as shown on the plans.
   b. Clay Pond Liner: If needed, construct the pond liner after lines and grades are obtained for the area needed and as shown in the plans. Liner placement will be constructed as in accordance with Section 202.
   c. Poly Liner: Install per manufacturer's specifications.
5. Standing Water: If standing water is encountered during excavation or construction, dewatering will be as in accordance with Section 902 and Section 906.
6. Stabilization: Stabilization will be in accordance with Section 908 and as stated on the plans.
7. Maintenance of the Stormwater Management Pond: Maintenance of the stormwater management facility will continue until final project acceptance. Maintenance will include annual mowing, removal of accumulated sediment, and anything else which would hinder the pond being accepted at project completion. Disposal of sediment is to be at a location approved by the Engineer. Refer to the plans on conversions of the facility from a sediment basin to a permanent facility.

D. Bioretention Area: Use the following construction methods for bioretention area. At no time should any construction equipment traverse within one foot of the designed bottom of the bioretention area. At no time should any stockpiling operation occur on or within ten feet of the bioretention area. Construct the bioretention area to the dimensions shown on the plans.

END OF SECTION

NOT FOR BIDDING PURPOSES

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NOT FOR BIDDING PURPOSES