



CHRISTINA SCHOOL DISTRICT

600 East 7th St.
Wilmington, DE 19801

Bancroft Elementary and Middle School – Phase 3

PROJECT MANUAL

BSA+A PROJECT #20.021

Contract No. CHR-22009D-NBANCON3

Volume 4
Divisions 26 through 33

Issued For Bid

January 4, 2023

ABHA | BSA+A

PROJECT MANUAL

Christina School District Bancroft Elementary and Middle School – Phase 3

Contract No. CHR-22009D-NBANCON3

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January 4, 2023

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1.1 DESIGN PROFESSIONALS OF RECORD

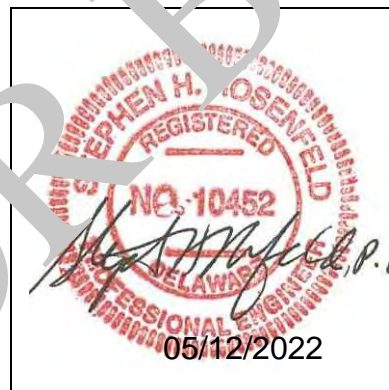
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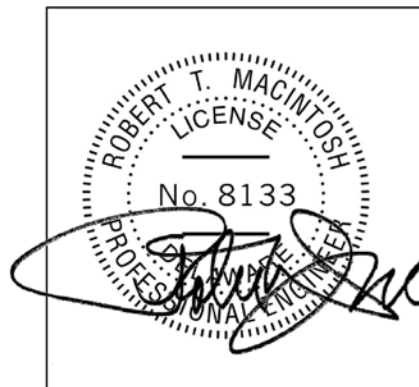
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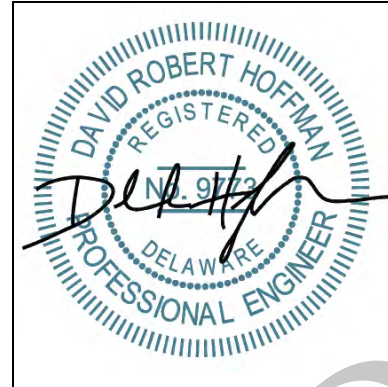


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SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL

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 ALTERNATES

- A. Refer to Division 01 Section 012300, *Alternates* for description of work under this Section affected by Alternates.

1.3 SUMMARY

- A. Section Includes:
 - 1. Electrical equipment coordination and installation.
 - 2. Sleeves for raceways and cables.
 - 3. Sleeve seals.
 - 4. Foam Duct Sealant.
 - 5. Grout.
 - 6. Plywood Backboards.
 - 7. Common electrical installation requirements.
- B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all electrical work.
- C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.
- D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange conduits, equipment, and other work generally as shown on the Contract Drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with Article "Submittals" specified below. The right is reserved to make reasonable changes in location of equipment, boxes, conduit/wiring, and devices, up to the time of rough-in or fabrication.
- E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.
- F. Coordinate the work under Division 26 with the work of all other construction trades.

- G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the Contract Documents.
- H. Arrange conduit, wiring, equipment, and other work generally as shown, providing proper clearances and access. Carefully examine all Contract Drawings and fit the work in each location without substantial alteration. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with Article "Submittals" as hereinafter specified. The right is reserved to make reasonable changes in location of equipment, conduit and wiring up to the time of rough-in or fabrication.

1.4 PERMITS AND FEES

- A. Obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.
- B. Permits and fees shall comply with Division 01 Section 010000, *General Requirements*.
- C. Notify Inspection Authorities to schedule inspections of work.
- D. Notify Architect and Engineer in advance of scheduled inspections.
- E. An electrical foreman, superintendent or other supervisor shall be in attendance for all scheduled inspections.

1.5 EXAMINATION OF SITE

- A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner will be permitted for Contractor's failure to do so.
- B. Examine and verify specific conditions described in individual Specifications sections.
- C. Verify that utility services are available, of the correct characteristics, and in the correct locations.

1.6 INTERPRETATION OF DOCUMENTS

- A. Any discrepancies between Drawings, Specifications, Drawings and Specifications, or within Drawings and Specifications shall be promptly brought to the attention of the Owner during the bidding period. No allowance shall subsequently be made by reason of failure to have brought said discrepancies to the attention of the Owner during the bidding period or of any error on the Bidder's part.

- B. The locations of products shown on Drawings are approximate. Place the devices to eliminate all interference with above-ceiling ducts, piping, etc. Where any doubt exists, the exact location shall be determined by the Owner.
- C. All general trades and existing conditions shall be checked before installing any outlets, power wiring, etc.
- D. Equipment sizes shown on the Drawings are estimated. Before installing any wire or conduit, obtain the exact equipment requirements and install wire, conduit, or other item of the correct size for the equipment actually installed. However, wire and conduit sizes shown on the Drawings shall be taken as a minimum and shall not be reduced without written approval from the Owner.
- E. Where variances occur between the Drawings and Specifications or within either document itself, the item or arrangement of better quality, greater quality, or higher cost shall be included in the Contract Price. The Engineer will decide on the item and manner in which the work shall be installed.
- F. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions, and accessories are not necessarily shown. Furnish and install all such items that may be required to fit the work to the conditions encountered. Arrange conduits, equipment, and other work generally as shown on the Contract Drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed Shop Drawings for approval in accordance with Article "Submittals" as herein after specified. The right is reserved to make reasonable changes in location of equipment, conduit/wiring, and devices, up to the time of rough-in or fabrication.
- G. Work not specifically outlined, but reasonably incidental to the completion of the work, shall be included without additional compensation from the Architect, Engineer, or Owner.
- H. Perform the work in a first-class, substantial and workmanlike manner. Any materials installed which do not present an orderly and neat workmanlike appearance shall be removed and replaced when so directed by the Engineer, at the Contractor's expense.
- I. Contact and coordinate service entrance equipment and layout with local power company prior to ordering or installing any service entrance equipment. Contractor shall furnish and install all incoming raceway and service entrance cables. If the power company plans to install cable and/or conduit, Contractor is responsible for proper coordination of cable, conduit, lug sizes, etc., for proper interface between utility owned/installed equipment and Contractor-installed equipment.
- J. The Owner shall make the application for electrical service and pay for all service charges, as discussed with the Contractor.
- K. The complete set of Architectural, Civil, Structural, Mechanical, and Electrical Drawings and Specifications apply to this work. The successful Bidder shall familiarize himself with all other related documents.

1.7 MATERIALS AND EQUIPMENT

- A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality. Existing items of equipment are being reconnected under another Division of these Specifications. The Contractor shall be responsible for connecting all utilities as shown on the Drawings, to equipment identified as existing.
- B. The Contractor shall only submit those manufacturers indicated in the Specification. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or its equal, subject to approval by Engineer. Substituted items shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Alternate manufacturers will not be considered unless the specific item indicates "or as approved equal". Submit all data necessary to determine suitability of substituted items, for approval.
- C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Substituted items, including items other than first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement, and application. Contractor, by providing other than the first named manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation. Adjustments and modifications shall include but not be limited to electrical, structural, support, and architectural work.
- D. Substitution will not be permitted for specified items of material or equipment where noted.
- E. All items of equipment furnished shall have a service record of at least five (5) years.

1.8 ELECTRICAL WORK UNDER OTHER DIVISIONS

- A. Mechanical Equipment and Systems:
 - 1. In general, power wiring and motor starting equipment for mechanical equipment and systems are furnished and installed under Electrical Division 26.
 - 2. Certain mechanical units are furnished from the factory with starters, contactors, transformers, fuses, wiring, etc., required for fans, pumps, etc. When this equipment is supplied from the factory, the Electrical Contractor must supply power circuit(s) to the unit and disconnecting means. Coordinate with Mechanical Contractor so that one and only one set of starters, fuses, switches, etc., is provided and installed.
 - 3. In general, control and interlock equipment for HVAC systems (including associated wiring, conduit, transformers, relays, contacts, etc.) is furnished under Division 23. Division 26 shall install and connect all such equipment as necessary.
 - 4. Controls, wiring, conduit, transformers, etc., for smoke, fire, and motor-operated dampers are provided under Division 23. Division 26 shall install and connect all such equipment.
- B. Architectural Equipment: In general, any electrically operated or controlled equipment furnished under architectural divisions shall be supplied with control wiring, transformers, contacts, etc. Provide power circuits and disconnects to such equipment and install all electrical control equipment related thereto.

- C. Owner Furnished Equipment: In general, Owner furnished equipment is either provided or wired by the equipment supplier. Provide power circuits to such equipment and make final connections to equipment being provided by the Owner.
- D. Carefully review the Contract Documents and coordinate the electrical work under the various Divisions.

1.9 FIRE SAFE MATERIALS

- A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA and ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.10 REFERENCED STANDARDS, CODES AND SPECIFICATIONS

- A. Specifications, Codes and Standards listed below are included as part of this Specification, latest edition:

- 1. ADA - Americans with Disabilities Act
- 2. ANSI - American National Standards Institute
- 3. ASTM - American Society for Testing and Materials
- 4. CSA - Canadian Standards Association
- 5. DNREC - Delaware Department of Natural Resources and Environmental Control
- 6. EPA - Environmental Protection Agency
- 7. FM - Factory Mutual
- 8. IBC - International Building Code
- 9. IEEE - Institute of Electrical and Electronics Engineers
- 10. NEC - National Electrical Code
- 11. NECA - National Electrical Contractors Association
- 12. NEMA - National Electrical Manufacturers Association
- 13. NFPA - National Fire Protection Association
- 14. OSHA - Occupational Safety and Health Act
- 15. UL - Underwriters' Laboratories

- B. The application standards of the local electric utility company.

- C. Electrical construction materials shall, where a listing is normal for the particular class of material, be listed in *Electrical Construction Materials List* of the Underwriters' Laboratories, Inc. (U.L.) and shall bear the listing label. Electrical equipment shall, where a listing is normal for the particular class of equipment, be listed in the *Electrical Appliance and Utilization Equipment List* of the Underwriters' Laboratories, Inc. (U.L.) and shall bear the listing label. Materials and equipment listed and labeled as "approved for the purpose" by other nationally recognized testing laboratory, inspection agency or approved organization (such as E.T.L. or Factory Mutual) shall be acceptable.

1.11 SUBMITTALS

- A. Product Data: For items specified in Part 2 of this Section.

1.12 SUBMITTALS, REVIEW AND ACCEPTANCE

- A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Architect/Engineer, to be in best interest of Owner.
- B. After acceptance of Material and Equipment List, submit six (6) copies, or more as required under the General Conditions, of complete descriptive data for all items. Data shall consist of Specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.
- C. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.
- D. Submittals will be reviewed for general compliance with design concept in accordance with Contract Documents, but dimensions, quantities, or other details will not be verified.
- E. Identify submittals, indicating intended application, location and service of submitted items. Refer to Specification sections or paragraphs and Drawings where applicable. Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For substituted items, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The Contractor shall be responsible for corrective action and maintaining the Specification requirements if differences have not been clearly indicated in the submittal.
- F. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Call attention, in writing, to deviation from contract requirements.
- G. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted. Use only final or corrected submittals and data prior to fabrication and/or installation.
- H. For any submittal requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold Contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

1.13 SHOP DRAWINGS

- A. Prepare and submit Shop Drawings for all electrical equipment, specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the Contract Drawings, or where the proposed installation differs from that shown on Contract Drawings.

- B. Submit Product Data and Shop Drawings including but not limited to the list below, in addition to provisions of the paragraph above. Identify all shop drawings by the name of the item and system and the applicable Specification paragraph number and Drawing number.
- C. Every submittal including, but not limited to the list below, shall be forwarded with its own transmittal as a separate, distinct shop drawing. Grouping of items/systems that are not related shall be unacceptable.

Items and Systems

1. Analysis and Coordination Study
2. Basic Electrical Materials
3. Cable – 600 Volt
4. Circuit Breakers
5. Conduit and Surface Raceway
6. Contractor and Subcontractor Qualifications
7. Controllers and Control Devices
8. Equipment Connections
9. Equipment Pads
10. Firestopping
11. Ground Conductors, Rods
12. Identification System
13. Lamps
14. Lighting Control Equipment
15. Light Fixtures
16. Low Voltage Fuses
17. Material and Equipment List
18. Motor Controllers
19. Occupancy and Vacancy Sensors
20. Outlet Boxes
21. Panelboards
22. Receptacles
23. Record and Information Booklet
24. Safety Switches
25. Schedule of Wiring
26. Sleeves, Hangers, Supports
27. Submittal Schedule
28. Surge Suppression Devices
29. Switchboards
30. Tests and Reports
31. Transformers
32. Wiring Devices
33. Wiring Diagrams

- D. Submittals shall include, but not be limited to, the following information: size, type, functional characteristics, compliance with standards in Division 26, required service access which shall be suitable for intended location and use, electrical service connections and requirements, and deviations from Contract Document requirements.

- E. Submit for approval any other shop drawings as required by the Architect/Engineer. No item listed above shall be delivered to the site, or installed, until approved. After the proposed materials have been approved, no substitution will be permitted except where approved by the Engineer.
- F. Submit for approval schematic diagrams of each electrical system installed in the building. Diagrams shall indicate device location, service, type, make, model number and the identification number of each device in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under glass and hung in each Main Equipment Room. Deliver the tracing or sepia from which the diagrams were reproduced to the Owner.
- G. Submittals shall include Riser Diagrams and Schematic Wiring Diagrams, complete conduit and wire requirements, outlet and junction box sizes and power requirements, for the following systems:
 - 1. Fire Alarm System
 - 2. Grounding and Bonding System
 - 3. Lighting Control System(s)
 - 4. Occupancy/Vacancy Sensor Layout
- H. For any shop drawing requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold Contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return for any reason.
- I. Prepare and submit a detailed schedule of values indicating the Contract costs for the major work items. Provide additional detail and information as requested by the Engineer.

1.14 DEFINITIONS

- A. *Approve*: To permit use of materials, equipment or methods conditional upon compliance with contract documents requirements.
- B. *Building Line*: Exterior wall of building.
- C. *Concealed*: Hidden from sight in chases, formed spaces, shafts, hung ceilings, embedded in construction.
- D. *Conduits* include conduit, all fittings, identification, and other accessories relative to such conduit.
- E. *Contractor*: The Electrical Contractor and any of his subcontractors, vendors, suppliers, or fabricators.
- F. *EPDM*: Ethylene-propylene-diene terpolymer rubber
- G. *Exposed*: Not installed underground or *concealed* as defined above.

- H. *Finished Spaces:* Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceiling, unexcavated spaces, crawl spaces, and tunnels.
- I. *Furnish and install or provide:* To supply, erect, install, and connect to complete for readiness for regular operation, the particular work referred to.
- J. *Location, Damp:* Locations protected from water and not subject to saturation with water or other liquids, but subject to moderate degrees of moisture. Examples of such locations include interior locations such as basements, crawlspaces, attics, cold-storage rooms, etc.
- K. *Location, Dry:* A location not normally subject to dampness or wetness. A dry location may temporarily be subject to dampness or wetness during building construction.
- L. *Location, Wet:* Locations subject to saturation with water or other liquids, locations exposed to weather, and installations underground or in concrete slabs or masonry in direct contact with the Earth. Examples of such locations include all exterior locations (including those under canopies, roofed open porches, etc.) commercial kitchens, and vehicle washing areas.
- M. *NBR:* Acrylonitrile-butadiene rubber.
- N. *Review:* Limited observation or checking to ascertain general conformance with design concept of the work and with information given in contract documents. Such action does not constitute a waiver or alteration of the contract requirements.

1.15 RECORD DRAWINGS

- A. Upon completion of the electrical installations, the Contractor shall deliver to the Architect one complete set of prints of the electrical Contract Drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings.
- B. Contractor shall incorporate all sketches, addendums, value engineering, change orders, etc., into record drawings prior to delivering the same to the Architect.

1.16 WARRANTY

- A. Contractor's attention is directed to warranty obligations contained in the General Conditions.
- B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of equipment manufacturer's warranties shall be included in the operations and maintenance manuals.
- C. The Contractor guarantees for a two (2) year period from the time of final acceptance by the Owner:
 - 1. That the work contains no faulty or imperfect material or equipment or any imperfect, careless, or unskilled workmanship.

2. That all work, equipment, machines, devices, etc. shall be adequate for the use to which they are intended, and shall operate with ordinary care and attention in a satisfactory and efficient manner.
3. That the Contractor will re-execute, correct, repair, or remove and replace with proper work, without cost to the Owner, any work found to be deficient. The Contractor shall also make good all damages caused to their work or materials in the process of complying with this section.
4. That the entire work shall be water-tight and leak-proof.

1.17 OPERATIONS AND MAINTENANCE MANUALS

- A. The Contractor shall have prepared six (6) copies of the Operations and Maintenance Manual and deliver these copies of the manual to the Owner. The manual shall be as specified herein. The manual must be approved and will not be accepted as final until so stamped.
- B. The manual shall be bound in a three-ring loose-leaf binder similar to National No. 3881 with the following title lettered on the front: *Operations and Maintenance Manual – Bayard Middle School Phase 1 - Electrical*. No sheets larger than 8-1/2 inches x 11 inches shall be used, except sheets that are neatly folded to 8-1/2 inches x 11 inches and used as pull-outs. Provide divider tabs and table of contents for organizing and separating information.
- C. Provide the following data in the manual:
 1. As first entry, an approved letter indicating the starting/ending time of Contractor's warranty period.
 2. Maintenance operation and lubrication instructions on each piece of equipment furnished.
 3. Complete catalog data on each piece of electrical equipment furnished including approved Shop Drawing/Submittal with Engineer's Comments (if any).
 4. Manufacturer's extended limited warranties on equipment.
 5. Provide sales and authorized service representatives names, address, and phone numbers of all equipment and subcontractors.
 6. Provide supplier and subcontractor's names, address, and phone number.
 7. Catalog data of all equipment, suppliers, etc. shall include wiring diagrams, parts list and assembly drawings.
 8. Access panel charts with index illustrating the location and purpose of access panels.
 9. Approved Electrical Certificates.
 10. Start-up report for equipment.
- D. Submit Operations and Maintenance Manual prior to anticipated date of Substantial Completion for Engineer review and approval. Substantial Completion requires that Operations and Maintenance Manuals be reviewed and approved.
- E. Post one (1) copy of all instructions, lists, charts and diagrams at the equipment mounted under glass or approved plastic cover.
- F. Deliver all instruction materials to the Owner prior to the formal instruction period.
- G. Upon completion of all work, thoroughly instruct the Owner's representatives in the proper operation and maintenance of all electrical equipment and systems.

- H. Instructions shall be done only after completed systems have been put into operation and tested for proper operation and performance.
- I. Instructions shall be given only by experts in the equipment or system and shall include descriptions and demonstrations of procedures of operation, data record keeping, etc.
- J. Furnish the necessary technicians, skilled workers, and helpers to operate the electrical systems and equipment of the entire project for one 8-hour day.
- K. Where specified in technical sections, provide longer periods required for specialized equipment.
- L. Instruct the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of systems and equipment.
- M. The Operations and Maintenance Manual shall be available at the time of the instructions for use by Instructors and Owner personnel.
- N. Schedule the general and specialized instruction periods for a time agreed upon by the Owner and Engineer.

1.18 INSTALLATION AND COORDINATION DRAWINGS

- A. Prepare, submit and use composite installation and coordination drawings to assure proper coordination and installation of the work. Drawings shall include, but not be limited to the following:
 - 1. Mechanical Rooms indicating transformers, panelboards, enclosures, boxes, conduits, mechanical equipment, ductwork, and piping, etc.
 - 2. Electrical Rooms indicating switchboards, panelboards, enclosures, boxes, transformers, conduits, wireways, etc.
- B. Draw plans to a scale not less than 1/4 inch equals one foot. Include plans, sections and elevations of the proposed work showing all equipment (mechanical, plumbing and electrical), conduit and wiring in the area involved. Fully dimension all work, horizontally and vertically. Show coordination with other work including piping, ductwork and other mechanical work, walls, doors, ceilings, columns, beams, joists and other architectural and structural work.
- C. Identify all equipment and devices on wiring diagrams. Where field connections are shown to factory-wired terminals, furnish manufacturer's literature showing internal wiring of equipment.
- D. Prepare, submit, and use scaled layout drawings indicating dimensions, clearances, and actual equipment dimensions. Layout Drawings shall include, but not be limited to the following:
 - 1. Building penetrations.

- E. Prepare scaled coordination drawings in accordance with the Specifications. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
1. Indicate the proposed locations of power, lighting, and all special system raceways, equipment, and materials. Include the following:
 - a. Working space and dedicated space clearances per the NEC.
 - b. Clearances for equipment disassembly required for periodic maintenance.
 - c. Exterior wall and foundation penetrations.
 - d. Fire-rated wall and floor penetrations.
 - e. Equipment connections and support details.
 - f. Sizes and locations of required concrete bases.
 2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction, including, but not limited to, the following: Major conduits and feeders.
 3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
 4. The successful Bidder shall be responsible for indicating all raceway, described in notes or indicated by home run symbols.
 5. The successful Bidder shall check all trades' Drawings, including Civil, Architectural, Structural, Plumbing, and Mechanical, to avoid possible demolition and installation conflicts.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.
 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. 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:
 - a. Advance Products & Systems, Inc.
 - b. Bridgeport Fittings, Inc.
 - c. Calpico, Inc.
 - d. GS Metals Corporation
 - e. Metraflex Co.
 - f. O-Z/Gedney
 - g. Pipeline Seal and Insulator, Inc.
 - h. Raco, Inc.
 2. Sealing Elements: EPDM, NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 3. Pressure Plates: Stainless Steel. Include two for each sealing element.
 4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.4 FOAM DUCT SEALANT

- A. Description: Two-part high-expansion foam duct sealant to keep water, acids, dust, gases, insects and rodents out of ducts (conduits).
- B. 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. American Polywater Corporation
- C. Finish of Design: FST Foam Sealant by American Polywater Corporation.
- D. The foam duct sealant shall be a two-part "blown" urethane foam with 98% closed cell content.
- E. The foam duct sealant shall have a compressive strength of 300 pounds (ASTM D1691), a tensile strength of 250 pounds (ASTM D1623), and a flexural strength of 450 pounds (ASTM D790).

- F. The foam duct sealant shall be compatible with common cable jacket materials. The cured foam shall be an inert solid that does not affect jacket materials.
- G. The foam duct sealant shall withstand temperatures from -20 degrees Fahrenheit to 200 degrees Fahrenheit and shall not lose function in direct sunlight
- H. The foam duct sealant shall be chemically resistant to gasoline, oils, dilute acids and bases, and most unsaturated hydrocarbons.
- I. The foam duct sealant shall foam and react in five to ten minutes at 70 degrees Fahrenheit.
- J. When installed, the sealant shall be capable of holding 7.25 psi air pressure continuously (equivalent of 16.4 feet water-head pressure).

2.5 PLYWOOD BACKBOARDS

- A. 4'x8'x 3/4" thick AC grade or better fire-retardant plywood.
- B. Backboards shall be painted with a minimum of two coats of flame retardant paint to match adjacent wall color.

2.6 FASTENERS

- A. All fasteners located in public spaces including classrooms, corridors, lobbies, toilet rooms, etc., shall be provided with tamper proof fasteners. Provide Phillips hardware as manufactured by Challenge Industries or approved equal.

PART 3 - EXECUTION

3.1 TEMPORARY FACILITIES

- A. General: Refer to the Division 01 Sections for general requirements of temporary facilities.
- B. Description: Furnish and install the necessary metering and distribution equipment for an adequate, 3-phase, 4-wire temporary electrical service and all temporary wiring and lighting, including step-down or step-up dry-type transformers as required. Exact requirements for temporary service will be determined by the General Contractor.
- C. Attention is directed to the Occupational Safety and Health Act (OSHA), Americans with Disabilities Act (ADA) and National Electrical Code (NEC) requirements for electrical work on construction sites.
- D. Materials:
 - 1. Lights at each floor in each stair. At least one light outlet per 900 square feet on each floor exclusive of stairs.
 - 2. One 20-ampere circuit with ground fault protection for each 7500 square feet of gross floor area per floor to which various trades may attach their cords.

3. One temporary power line in each corridor elevator and lobby, including connections to saws, if required, with ground fault protection.
4. Power for testing and operating of elevators.
5. Temporary lighting for stripping forms for all floors below grade.
6. Power for crane operation if required.

E. Installation: Temporary lighting shall provide minimum foot candle levels for construction as follows:

AREA	FOOT CANDLE LEVEL
General construction area lighting, corridors, hallways and exit ways.	5
Electrical equipment rooms, active storerooms, shops, locker and dressing areas	10

F. The Contractor shall pay for all energy charges for temporary service. Provide temporary construction power. Remove all temporary power installations and connections after permanent power is established and/or prior to completion of the project.

3.2 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Install equipment with working space and dedicated space in strict accordance with 2008 NEC Article 110.26.
- E. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- F. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- G. Verify exact electrical service requirements for each piece of equipment receiving electrical service. Provide proper service for each.
- H. Include any and all items required by the National Electrical Code and/or field conditions for the proper connection and installation of each piece of equipment.
- I. Right of Way: Give to piping systems installed at a required slope.

- J. Coordinate electrical work with architectural items and equipment by others. Typical equipment refers to, but is not limited to, the following:
1. Countertops, Casework and Cabinets.
 - a. Do not install outlets, switches, etc., behind casework, cabinets, etc.
 - b. Data, phone, and other low voltage system outlets shall be mounted above the counter tops to match power outlets in the same areas.
 - c. Coordinate counter top outlets with drilling of casework/counters.
 - d. Coordinate surface raceways and outlets above and below counters with approved casework shop drawings to avoid conflicts with sinks and other appurtenances.
 2. Kitchen Equipment.
 - a. Verify kitchen equipment nameplates and connection requirements prior to rough-in.
 - b. Fans and Exhaust Hoods.
 - c. Dishwasher Hoods and Fans.
 3. Classroom Equipment.
 - a. Verify classroom equipment nameplates and connection requirements prior to rough-in.
 - b. Exhaust Hoods and Fume Hoods.

3.3 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls. Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies. Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.

- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements of Division 07 Section 079200 *Joint Sealants*.
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements of Division 26 Section 260528 *Electrical Firestopping*.
- K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeve and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25 mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- M. Cut sleeves to length for mounting flush with both surfaces of walls.

3.4 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing element 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.

3.5 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 26 Section, *Electrical Firestopping*.

3.6 SUPPORTS, HANGERS AND FOUNDATIONS

- A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workmanlike manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.

- B. Supports, hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. All exterior hangers shall be constructed of stainless steel utilizing stainless steel rods, nuts, washers, bolts, etc.
- C. Installing Equipment Foundations (Housekeeping Pads):
1. Provide four (4) inch high concrete foundations (housekeeping pads) for all floor-mounted equipment extending a minimum of 6 inches beyond equipment bases for interior equipment and a minimum of 12 inches beyond equipment bases for exterior equipment, unless otherwise noted. Furnish foundations, bolts, sleeves, and appurtenances and set under the section furnishing the equipment. Anchor the concrete foundations by dowels inserted into the floor slab. Provide welded wire fabric reinforcement, chamfer exposed edges and corners, and finish exposed surfaces smooth.
 2. Unless otherwise specified, provide all concrete work required in accordance with the requirements of Division 03.
 3. Equipment shall be properly aligned. Level and grout equipment where necessary. Support conduit independently of equipment and so as not to cause a strain or thrust.
 4. Determine exact location of all equipment, foundations, and supports and Shop Drawings of equipment have been approved.
- D. Where new concrete housekeeping pads are placed on existing concrete, saw cut the existing concrete to the perimeter dimension of the new pad to a depth of ½ inch. Break out the top ½ inch area of the existing concrete. Add stubs of #4 rebar angled into the existing concrete at a depth of approximately 50 percent of the existing slab thickness. The top portion of the rebar stub shall extend into the new pad by approximately 50 percent of its thickness. Furnish one rebar stub per every two square feet of new pad. Chemically bond the new concrete to the existing concrete.

3.7 PROVISIONS FOR ACCESS

- A. The Contractor shall provide access panels and doors for all concealed equipment, and other devices requiring maintenance, service, adjustment or manual operation.
- B. Where access doors are necessary, furnish and install manufactured painted steel door assemblies consisting of hinged door, key locks, and frame designed for the particular wall or ceiling construction. Properly locate each door. Door sizes shall be a 12 inches x 12 inches for hand access, 18 inches x 18 inches for shoulder access and 24 inches x 24 inches for full body access where required. Review locations and sizes with Architect prior to fabrication. Provide U.L. approved and labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, Mifab, or approved equal.
1. Acoustical or Cement Plaster: Style B
 2. Hard Finish Plaster: Style K or L
 3. Masonry or Dry Wall: Style M
- C. Where access is by means of liftout ceiling tiles or panels, mark each ceiling grid using small color-coded and numbered tabs. Provide a chart or index for identification. Place markers within ceiling grid not on ceiling tiles.

- D. Access panels, doors, etc. described herein shall be furnished under the section of Specifications providing the particular service and to be turned over to the pertinent trade for installation. Coordinate installation with installing Contractor. All access doors shall be painted in baked enamel finish to match ceiling or wall finish.
- E. Submit shop drawings indicating the proposed location of all access panels/doors. Access doors in finished spaces shall be coordinated with air devices, lighting and sprinklers to provide a neat and symmetrical appearance.
- F. Provide sufficient access and working space for repair and maintenance about all lighting and electrical equipment to permit ready and safe operation and maintenance of such equipment OSHA 29 CFR 1910 Subpart D and 1910.303(g).

3.8 PAINTING AND FINISHES

- A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc. shall be stainless steel.
- B. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.
- C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.
- D. Protect all finishes and restore any finishes damaged as a result of work under Division 26 to their original condition.
- E. The preceding requirements apply to all work, whether exposed or concealed, as defined herein.
- F. Remove all construction marking and writing from exposed equipment, ductwork, piping and building surfaces. Do not paint manufacturer's labels or tags.
- G. All exterior equipment and conduits shall be painted to match adjacent surface in color as selected by Architect unless otherwise indicated by the Architect.
- H. All exposed conduit, equipment, etc. in finished spaces shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.

3.9 COLOR SELECTION

- A. Color of finishes shall be as selected by the Architect.

3.10 PROTECTION OF WORK

- A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

- B. Cover temporary openings in conduits and equipment to prevent the entrance of water, dirt, debris, or other foreign matter. Deliver conduits with factory applied end caps.
- C. Cover or otherwise protect all finishes.
- D. Replace damaged materials, devices, finishes and equipment.
- E. Protect stored conduits from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, where stored inside.

3.11 OPERATION OF EQUIPMENT

- A. Clean all systems and equipment prior to initial operation for testing, or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.
- B. Where specified, or otherwise required, provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment. Where factory start-up of equipment is not specified, provide field start-up by qualified technician.
- C. Submit factory start-up sheets or field start-ups sheets for all equipment prior to the commencement of testing.
- D. Do not use electrical systems for temporary services during construction, unless approved by Owner in writing. Refer to Division 01 Section 5000 *Temporary Facilities and Controls*.
- E. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items.

3.12 TESTING AND ADJUSTMENT

- A. Perform all tests which are specified or required to demonstrate that the work is installed and operating properly. When formal tests are required, give proper notices and perform all necessary preliminary tests to assure that the work is complete and ready for final test.
- B. Adjust all systems, equipment and controls to operate in a safe, efficient and stable manner.
- C. On all circuits 600 volts or less, provide circuits that are free from ground faults, short circuits and open circuits.
- D. Other tests of a specific nature for special equipment shall be as specified under the respective equipment.
- E. Submit all test results to the Architect/Engineer for approval.

3.13 WALL AND FLOOR PENETRATIONS

- A. All penetrations of partitions, ceilings, roofs and floors by or conduit under Division 26 shall be sleeved, sealed, and caulked airtight for sound and air transfer control. Penetrations of mechanical room partitions, ceilings, and floors shall be as specified in Division 26.
- B. All penetrations of fire rated assemblies shall be sleeved, sealed, caulked and protected to maintain the rating of the wall, roof, or floor. Fire Marshal approved U.L. assemblies shall be utilized. See Division 26 Section, *Electrical Firestopping*.
- C. Where penetrating through exterior walls or below grade, provide waterproof pipe penetration seals, as specified in another division of these Specifications.
- D. Provide conduit escutcheons for all exposed conduit penetrations in finished interior spaces and all exposed exterior penetrations. Escutcheons shall match those provided under Division 23.
- E. Conduit sleeves:
 - 1. Galvanized steel pipe, standard weight where pipes are exposed and roofs and concrete and masonry walls. On exterior walls provide anchor flange welded to perimeter.
 - 2. Twenty-two (22) gauge galvanized steel elsewhere.

3.14 EQUIPMENT BY OTHERS

- A. This Contractor shall make all system connections required to equipment furnished and installed under other divisions or furnished by the Owner. Connections shall be complete in all respects to render this equipment functional to its fullest intent.
- B. It shall be the responsibility of the supplier of the equipment to furnish complete instructions for connections. Failure to do so will not relieve the Contractor of any responsibility for improper equipment operation.

3.15 PHASING

- A. Refer to Architectural Specifications and Contract Drawings for any required phasing.
- B. Maintain building egress and traffic ways at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and Authorities Having Jurisdiction (AHJ).
- C. Provide dust barriers/partitions, penetration closures, etc., to ensure safety of building occupants and protection of existing surroundings.
- D. The Building shall remain watertight at all times.
- E. Refer to phasing plans for additional requirements.

- F. Within thirty (30) days of Award of Contract, the Contractor shall submit a minimum of six (6) copies of the proposed Phasing Plan (Drawings and detailed written description) to the Architect for review and approval based on the general and specific requirements indicated on the Drawings and Specifications. The phasing plan shall reflect the work of all trades. The phasing plan shall be updated as often as needed (i.e., major deviations and/or modified sequence of events) and reviewed during each progress meeting so the Owner and Architect can be aware of the areas of construction and progress as it relates to the approved schedule.
- G. While work is in progress, except for designated short intervals during which connections are made, continuity of service shall be maintained to all existing systems. Interruptions shall be coordinated with the Owner as to time and duration. The Contractor shall be responsible for any interruptions to service and shall repair any damages to existing systems caused by his operations.

3.16 OUTAGES

- A. Provide a minimum of fourteen (14) days' notice to schedule outages. The Contractor shall include in their bid outages and/or work in occupied areas to occur on weekends, holidays, or at night. Coordinate and get approval of all outages with the Owner.
- B. Submit *Outage Request Form*, attached at the end of this Section, to Owner for approval.

3.17 CUTTING AND PATCHING

- A. Accomplish all cutting and patching necessary for the installation of work under Division 26. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, perform work in neat and workmanlike manner. Restore disturbed work to match and blend with existing construction and finish, using materials compatible with the original. Use mechanics called in the particular trades required.
- B. Do not cut structural members without approval from the Architect or Engineer.

3.18 PENETRATION OF WATERPROOF CONSTRUCTION

- A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are necessary, furnish and install necessary curbs, sleeves, flashings, fittings and caulking to make penetrations absolutely watertight.
- B. Where conduits penetrate roofs, flash pipe with Stoneman *Stormite*, Pate or approved equal, roof flashing assemblies with skirt and caulked counter flashing sleeve.
- C. Furnish and install pitch pockets or weather tight curb assemblies where required.

- D. Furnish and install curbs, vent assemblies, and sleeves specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions. The Contractor shall be responsible for sleeve sizes and locations. All roof penetrations shall be installed in accordance with manufacturer's instructions, the National Roofing Contractors Association, SMACNA, and as required by other divisions of these Specifications.

3.19 CONCRETE AND MASONRY WORK

- A. Furnish and install concrete and masonry work for equipment foundations, supports, pads, and other items required under Division 26. Perform work in accordance with requirements of Division 03 and other applicable Divisions of these Specifications.
- B. Concrete shall test not less than 3,000 psi compressive strength after 28 days.
- C. Grout shall be non-shrink, high strength mortar, free of iron or chlorides and suitable for use in contact with all metals, without caps or other protective finishes. Apply in accordance with manufacturer's instructions and standard grouting practices.
- D. Installing Outdoor Equipment Foundations:
 - 1. Provide equipment foundations as indicated in Article "Supports, Hangers, and Foundations" in this Section.
 - 2. Place reinforcement accurately in position shown, securely fasten and support to prevent displacement before or during pouring. Clean, bend, place, and splice reinforcement in accordance with approved shop drawings. Lap ends and sides of mesh reinforcement in slabs not less than one inch. Coverage of mesh reinforcing shall be as follows:
 - a. Slabs - 3/4 inch
 - b. Concrete poured against earth - 3 inches
 - c. Other locations - 2 inches
 - 3. Properly align, level, and ground all equipment where necessary.

3.20 CONNECTIONS AND ALTERATIONS TO EXISTING WORK

- A. Unless otherwise noted on the Drawings, where existing electrical work is removed, including hangers, to a point below finished floors or behind finished walls and capped, such point shall be far enough behind finished surfaces to allow for installation of normal thickness of required finish material.
- B. Where work specified in Division 26 connects to existing equipment, conduits, etc., Contractor shall perform all necessary alterations, cuttings, fittings, etc., of existing work as may be necessary to make satisfactory connections between new and existing work, and to leave completed work in a finished and workmanlike condition.
- C. Where the work specified under Division 26, or under other Divisions, requires relocation of existing equipment, conduit etc., Contractor shall perform all work and make necessary changes to existing work as may be required to leave completed work in a finished and workmanlike condition.

- D. Where the relocation of existing equipment is required for access or the installation of new equipment, the Contractor shall temporarily remove and/or relocate and re-install as required to leave the existing and new work in a finished and workman like condition.

3.21 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
 - 5. To provide working space and dedicated space clearances per 2005 NEC Article 110.26.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in this Section, Article "Provisions for Access".
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 26 Section 260528 *Electrical raceway stoppers*.

3.22 DEMOLITION

- A. Unless otherwise noted all existing equipment, conduit, wire, etc., shall remain.
- B. Where existing equipment is indicated to be removed, all associated conduit, power, controls, insulation, hangers, supports and housekeeping pads, etc., shall also be removed. Patch, paint and repair walls/roof/floor to match existing and/or new finishes.
- C. The Contractor shall be responsible for visiting the site and determining the existing conditions in which the work is to be performed.
- D. Refer to phasing plans for additional requirements.
- E. Remove any abandoned conduits in existing floors, walls, pipe tunnels, ceilings, etc., conflict with new work, remove abandoned conduits as necessary to accommodate new work.
- F. The location of all existing equipment, conduits etc., indicated is approximate only and shall be checked and verified. Provide all new electrical work required to connect to or clear existing work as applicable.
- G. Maintain egress at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and the Authorities Having Jurisdiction (AHJ).

- H. Make provisions and include in bid all costs associated with confined entry/space requirements in crawl spaces and all other applicable OSHA regulations.
- I. Where required to maintain the existing systems in operation, temporarily backfeed existing systems from new equipment. Contractor shall temporarily extend existing conduit systems to new conduit systems.
- J. At completion of project all temporary conduit, wires, etc., shall be removed in their entirety.
- K. Existing conduit, equipment, wiring, etc., not required for re-use or re-installation in this project, shall be removed from the project site.
- L. Deliver to the Owner, on the premises where directed, existing equipment and materials which are removed and which are desired by the Owner or are indicated to remain the property of the Owner.
- M. All other materials and equipment which are removed shall become property of the Contractor and shall be promptly removed, from the premises, and disposed of by the Contractor, in an approved manner. Contractor shall be responsible for proper disposal of all removed equipment containing PCB's.
- N. Where conduit and wiring are removed, remove all conduit hangers which were supporting the removed conduit. Patch the remaining penetration voids with like materials and paint to match existing construction.
- O. Where required, provide and coordinate removal and re-installation of existing equipment. Take care to protect materials and equipment indicated for reuse. Contractor shall repair or replace items which are damaged. Contractor shall have Owner's representative present to confirm condition of equipment prior to demolition.
- P. Before demolition begins, and in the presence of the Owners representative, test and note all deficiencies in all existing systems affected by demolition but not completely removed by demolition. Provide a copy of the list of system deficiencies to the Owner and the Engineer. Videotape existing conditions in each space prior to beginning demolition work.
- Q. The Owner shall have the right of refusal for all fixtures, devices and equipment removed by the Contractor.
- R. All devices and equipment designated by the Owner to remain the property of the Owner shall be moved and stored by the Contractor at a location on site as designated by the Owner. It shall be the Contractor's responsibility to store all devices and equipment in a safe manner to prevent damage to the stored.
- S. All existing equipment refused by the Owner shall become the property of the Contractor and shall be removed from the site by the Contractor in a timely manner and disposed of in a legal manner.
- T. Work Abandoned in Place: Cut and remove conduit a minimum of 2 inches beyond face of adjacent construction. Cap and patch surface to match existing finish.

- U. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.
- V. Terminate services and utilities in accordance with local laws, ordinances, rules and regulations.

3.23 EXCAVATION AND BACKFILLING

A. General:

1. Perform all necessary excavation, or installation of work under Division 26, in whatever materials or conditions encountered, using suitable methods and equipment.
2. Accurately establish required lines and grades and properly locate the work.
3. Determine the locations of all existing utilities before commencing the work.

B. Excavation: (Refer also to other portions of the Specifications)

1. Excavate only the required elevations. If excavation is carried below the foundation lines or other required limits, backfill the excess with concrete.
2. Keep banks of trenches as nearly vertical as possible, and provide sheet piling and/or shoring as required for protection of work and safety of personnel. Follow local, State, OSHA, and MOSHA Guidelines.
3. Keep excavations dry. Protect excavations from freezing.

C. Backfilling: (Refer also to other portions of the Specifications)

1. Backfill excavations to the required elevations and restore surfaces to their original or required conditions.
2. Backfill shall be similar material, free from objectionable matter such as rubbish, roots, stumps, brush, rocks and other sharp objects. Unless otherwise indicated, suitable material from the excavation may be used for backfill.
3. Carefully place and mechanically tamp backfill in layers not exceeding 12 inches loose thickness. Compact to 95 percent minimum.
4. Do not backfill against frozen material. Do not use frozen material for backfill.

END OF SECTION

OUTAGE REQUEST

DATE APPLIED: _____ BY: _____

DATE FOR OUTAGE: _____ FIRM: _____

START OUTAGE-TIME: _____ DATE: _____

END OUTAGE -- TIME: _____ DATE: _____

AREAS AND ROOMS: _____

FLOOR(S): _____

AREA(S): _____

ROOM(S): _____

WORK TO BE PERFORMED: _____

SYSTEM(S): _____

REQUEST APPROVED BY: _____
(FOREMAN OR OTHER PERSON IN CHARGE)

(FOR OWNER'S USE ONLY):

APPROVED: _____

YES ___ NO ___ BY: _____ DATE: _____

DATE/TIME-AS REQUESTED: _____ OTHER: _____

OWNER'S PRESENCE REQUIRED: _____

YES: ___ NO: ___ NAME: _____

POINT OF CONTACT: _____ PHONE: _____

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NOT FOR BID

DIVISION 26 SECTION 26 05 10
ELEVATOR EQUIPMENT WIRING AND PROVISIONS
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NOT FOR BID

SECTION 26 05 10 - ELEVATOR EQUIPMENT WIRING AND PROVISIONS

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 WORK INCLUDED

- A. Power wiring and devices to elevator drive equipment.
- B. Power wiring and devices for elevator cab equipment.
- C. Additional miscellaneous service connections may include:
 - 1. Telephone service connection.
 - 2. Public address system connection.
 - 3. Emergency power system connections.
 - 4. Elevator lobby smoke detector connections.
 - 5. Safety light and outlet in elevator pit.
- D. Elevator control wiring and interlock controls not included.
- E. All electrical work specified to be done by others in Division 14.

1.3 COORDINATION

- A. Coordinate with elevator contractor, elevator inspector, electrical inspector, and Fire Marshal prior to installation.
- B. Prepare coordination drawings and sketches as needed to provide complete information.
- C. Coordinate with other trades to avoid foreign equipment, not dedicated to serving Elevator Machine Room, from being installed in Elevator Machine Room.
- D. Coordinate entire installation with elevator system installer prior to rough-in and prior to installation of equipment.
- E. Coordinate location of lights, machines, and equipment installed in elevator pit and machine rooms with elevator system installed on site prior to installation.

1.4 REGULATIONS

- A. Comply with NEC.
- B. Comply with NFPA: NFPA 101 Life Safety Code.
- C. Comply with ANSI/ASTM Elevator Code.
- D. Comply with BOCA Building Code.

PART 2 - PRODUCTS

2.1 ELECTRICAL PROVISIONS

- A. Provide lockable heavy duty type fused disconnect switches for each circuit serving elevator car power (lighting/ventilation), for elevator drive/controller, and if required for signal power. Provide fuses sized as directed by elevator supplier. Provide in accordance with NEC Articles 620-22 (a), 620-53, and 620-85.1. Disconnects shall be lockable in the “open” position and the “closed” position. Disconnect for elevator drive/controller shall be shunt trip type. Provide each disconnect with an equipment nameplate to identify the location of the supply side overcurrent protection device.
 - 1. Disconnect for elevator drive/controller shall be shunt trip type. Connect to heat detectors as required. Provide power to shunt trip unit as required. Size per elevator supplier directions.
- B. Locate elevator disconnect switches adjacent to elevator equipment room door. Locate on strike side of door. Provide one disconnect for each elevator controller unit.
- C. Provide all power wiring from source through disconnect to elevator controller to motor.
- D. Provide 1-inch conduit, with two (2) category 6 cables from each elevator controller to nearest telephone wiring closet.
- E. Provide lock-clip device on each circuit breaker serving elevator car and room, both lighting and power circuits.
- F. Provide all wiring and mount exterior alarm bell. Feed from emergency source.
- G. Provide lighting fixture with lamp guard and duplex GFCI receptacle 72-inches above elevator pit. Provide switch adjacent to access ladder near the hoistway door, 36-inch above door sill. Provide switch, receptacle, lighting fixture on every other floor above the lowest level for each elevator. Provide in accordance with NEC Articles 620.24 and 620.85.
- H. All traveling cables, control stations, control station wiring and final control connections at the controller shall be furnished and installed under Division 14.

- I. Provide elevator machine room lighting and receptacles in accordance with NEC Articles 620.23 and 620.85. Locate lights in room to provide optimum illumination for all machinery, and the front and rear of each controller. Provide light switch by the machine room entrance.
- J. Provide for each elevator car a separate dedicated 120 volt, 15 ampere branch circuit with a lockable disconnect switch in the elevator machine room, with two #12 and one #12 ground in 3/4-inch conduit, to each elevator controller, to serve car lighting, ventilation and car top receptacle.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Locate all disconnect devices and elevator machine room light switch on lock side of door within elevator machine room. Devices are typically located within 1'-6-inches of entrance.

END OF SECTION

NOT FOR BID

DIVISION 26 SECTION 26 05 13
MEDIUM-VOLTAGE CABLES
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END OF SECTION 6

NOT FOR BID

SECTION 26 05 13 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cables.
2. Connectors.
3. Solid terminations.
4. Separable insulated connectors.
5. Medium-voltage tapes.
6. Arc-proofing materials.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Indicate location of each cable, splice, and termination.
- B. Material Certificates: For each type of cable and accessory.
- C. Source quality-control reports.
- D. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- 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 IEEE C2 and NFPA 70.
- C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 CABLES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Okonite Company.
 2. Southwire Company.
 3. Superior Essex, Inc.
 4. Rome Cable Company.
 5. Aetna Insulated Wire, Inc.
 6. Kerite Company.
 7. General Cable; General Cable Corporation.
- B. Cable Type: Type MV 105.
- C. Conductor Insulation: Ethylene-propylene rubber.
1. Voltage Rating: 25 kV.
 2. Insulation Thickness: 100 percent insulation level.
- D. Conductor: Aluminum.
- E. Comply with UL 1072, AEIC CS8, and ICEA S-94-649.
- F. Conductor Stranding: Solid.
- G. Shielding: Solid copper wires, helically applied over semi-conducting insulation shield.
- H. Cable Jacket: Chlorosulfonated polyethylene.

2.3 CONNECTORS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. 3-M Manufacturing Company
 2. InVent (Prythem)
 3. TE Connectivity
 4. G&V
- B. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.
- C. Copper-Conductor Connectors: Aluminum barrel crimped connectors.

2.4 SOLID TERMINATIONS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. 3-M Manufacturing Company
 2. nVent (Raychem)
 3. TE Connectivity
 4. G&W
- B. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.
- C. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.
1. Class 1 Terminations:
 - a. Modular type, furnished as a kit, with stress-relief tube; multiple, molded, cone-rubber, insulator modules; shield ground strap; and compression-type connector.
 - b. Heat-shrink type with heat-shrink inner stress control and outer non-tracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.

2.5 SEPARABLE INSULATED CONNECTORS

- A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include but are not limited to, the following:
1. 3-M Manufacturing Company
 2. nVent (Raychem)
 3. TE Connectivity
 4. G&W
- C. Load-Break Cable Terminators: Elbow type units with 200 A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
- D. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.
- E. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 MEDIUM-VOLTAGE TAPES

- A. Description: Electrical grade, insulating tape rated for medium voltage application.

- B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. 3-M Manufacturing Company
 - 2. nVent (Raychem)
 - 3. TE Connectivity
 - 4. G&W
- C. Ethylene/propylene rubber-based, 30 mil (0.76 mm) splicing tape, rated for 130 deg C operation. Minimum 3/4 inch (20 mm) wide.
- D. Silicone rubber-based, 12 mil (0.30 mm) self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inch (38 mm) wide.
- E. Insulating-putty, 125 mil (3.175 mm) elastic filler tape. Minimum 1-1/2 inch (38 mm) wide

2.7 ARC-PROOFING MATERIALS

- A. Description: Fire retardant, providing arc flash protection.
- B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. 3-M Manufacturing Company
 - 2. nVent (Raychem)
 - 3. TE Connectivity
 - 4. G&W
- C. Tape for First Course on Metal Objects: 1 mil (250 micrometer) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
- D. Arc-Proofing Tape: Fire proof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, and compatible with cable jacket.
- E. Glass-Cloth Tape: Pressure sensitive adhesive type, 1 inch (25 mm) wide.

2.8 SOURCE QUALITY CONTROL

- A. Test and inspect cables according to ICEA S-97-682 and ICEA S-94-649 before shipping.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cables according to IEEE 576.

- B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inch (1200 to 1800 mm) on the pull rope.
1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
 2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.
- C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
 2. Use pulling means, including fish tape, cable, rope, and basket, have cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
 3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
 4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.
- D. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.
- E. Install cable splices at pull points and elsewhere as indicated, use standard kits.
- F. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.
- G. Install separable insulated-connector components as follows:
1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
 2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
 3. Standoff Insulator: At each terminal junction, with one on each terminal.
- H. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape in manufacturer's written instructions, apply arc proofing as follows:
1. Clean cable sheath.
 2. Wrap metallic cable components with 10 mil (250 micrometer) pipe-wrapping tape.
 3. Smooth surface contours with electrical insulation putty.
 4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
 5. Band arc-proofing tape with two layers of 1 inch (25 mm) wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.

- I. Seal around cables passing through fire-rated elements according to Section 078413 "Penetration Firestopping."
- J. Install fault indicators on each phase where indicated.
- K. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.
- L. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 - 2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
 - 3. Perform direct-current High Potential test of each new conductor according to NETA ATS, Ch. 7.3.3. Do not exceed cable manufacturer's recommended maximum test voltage.
 - 4. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
 - 5. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
- B. Medium-voltage cables will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION

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DIVISION 26 SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
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SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

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 Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

1.3 SUBMITTALS

- A. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Indicate procedures and values obtained.
- B. Product Data: Provide for each cable assembly type, wire, cables, conductors, and connectors.
- C. Factory Test Reports: Indicate procedures and values obtained.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.
- E. Project Record Documents: Record actual locations of components and circuits.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: In addition to requirements specified in Division 01 Section 014000, *Quality Control*, an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907; or shall be a full-member company of the International Electrical Testing Association.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3 of this Section.

- B. Listing and Labeling: Provide wires and cables specified in this Section that are listed and labeled.
1. The Terms *Listed and Labeled*: As defined in NFPA 70, Article 100.
 2. Listing and Labeling Agency Qualifications: A *Nationally Recognized Testing Laboratory* as defined in OSHA Regulation 1910.7.
- C. Comply with NEMA/Insulated Cable Engineers Association (ICEA) Standards.
- D. Comply with NECA Standard of Installation.
- E. Comply with NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- F. American Society for Testing and Materials (ASTM): Comply with requirements of the following:
1. B1: Standard Specification for Hard-Drawn Copper Wire
 2. B2: Standard Specification for Medium-Hard-Drawn Copper Wire
 3. B3: Standard Specification for Soft or Annealed Copper Wire
 4. B8: Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
 5. D753: Standard Specification for General Purpose Polychloroprene Jacket for Wire and Cable
- G. Electrical Testing Laboratories (ETL): Provide wiring, cabling and connector products which are ETL listed and labeled.
- H. Institute of Electrical and Electronics Engineers (IEEE). Comply with the following standards which apply to wiring systems:
1. 82: Test procedure for Impulse Voltage Tests on Insulated Conductors
 2. 241: Recommended Practice for Electric Power Systems in Commercial Buildings
- I. NFPA: Comply with NFPA 70 requirements for construction, installation and color coding of electrical wire, cable and connections.
- J. National Electrical Manufacturer's Association (NEMA): Comply with requirements of the following:
1. WC: Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
 2. WC5: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
- K. UL: Provide material conforming to the following standards:
1. UL 83 - Thermoplastic-Insulated Wires and Cables.
 2. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors
 3. UL 854 - Service-Entrance Cables
- L. UL Labels: Provide wiring, cabling and connector products which are UL listed and labeled.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver wires and cables according to NEMA WC 26, *Wire and Cable Packaging*.
- B. Storage: Store wire and cable in a clean dry space in original containers. Protect products from weather, damaging fumes, construction debris and traffic.
- C. Handling: Handle wire and cable carefully to avoid abrading, puncturing and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

1.6 COORDINATION

- A. Coordinate layout and installation of cables with other installations.
- B. Revise locations and elevations from those indicated, as required to suit field conditions and as approved by Engineer and Architect.
- C. Determine required separation between cables and other work.
- D. Determine cable routing to avoid interference with other work.

1.7 PROJECT CONDITIONS

- A. Verify that field measurements are as shown on Drawings.
- B. Conductor sizes are based on copper.
- C. Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet Project Conditions.
- D. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

PART 2. PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Wires and Cables:
 - a. American Insulated Wire Corp.; Leviton Manufacturing Co.
 - b. BICC Brand-Rex Company.
 - c. Carol Cable Co., Inc.

- d. Senator Wire & Cable Company.
 - e. Southwire Company.
 - f. Colonial Wire Company.
2. Connectors and Accessories for Wires and Cables:
- a. AMP Incorporated.
 - b. Buchanan.
 - c. General Signal; O-Z/Gedney Unit.
 - d. Monogram Company; AFC.
 - e. NSI Industries, Inc.
 - f. Square D Company; Anderson.
 - g. 3M Company; Electrical Products Division.
3. Metal Clad (MC) Cable
- a. Alcan Cable
 - b. Atkore AFC Cable Systems
 - c. Encore Wire Corporation
 - d. General Cable
 - e. Nexans
 - f. Prysmian Cables and Systems
 - g. Service Wire Company
 - h. Southwire Company
 - i. United Copper Industries
- 2.2 BUILDING WIRES AND CABLES
- A. UL-listed building wires and cables with conductor material, insulation type, cable construction and rating as specified herein.
 - B. Building wires and cables shall be annealed (soft) copper, 600 volt, Type THHN/THWN (dual-rated) single conductors rated 90°C dry / 75°C wet, with a minimum conductivity of 98 percent at 20°C (68°F), or a maximum resistivity of 1.7 micro-ohms per centimeter.
 - C. Conductors shall meet or exceed requirements of all applicable ASTM specifications, UL Standard 88, UL Standard 1581, NEMA WC 70, Federal Specification A-A-59544 and shall be RoHS/REACH Compliant.
 - D. Conductors shall be solid for No. 10 AWG and smaller, and stranded for No. 8 AWG and larger.
 - E. Building wire and cables shall be color-coded using colors factory impregnated throughout the insulation and jacket. The following color code convention(s) shall be used:
 - 1. 208/120-Volt, 3-Phase, 4-Wire System:

- a. Phase A: Black
- b. Phase B: Red
- c. Phase C: Blue
- d. Neutral: White
- e. Ground: Green

2. 480/277-Volt, 3-Phase, 4-Wire System:

- a. Phase A: Brown
- b. Phase B: Orange
- c. Phase C: Yellow
- d. Neutral: Gray
- e. Ground: Green

- F. Rubber insulation material shall comply with NEMA WC 3.
- G. Thermoplastic insulation material shall comply with NEMA WC 5.
- H. Cross-Linked Polyethylene insulation material shall comply with NEMA WC 7.
- I. Ethylene Propylene Rubber insulation material shall comply with NEMA WC 8.

2.3 CONNECTORS AND SPLICES

- A. UL-listed, factory-fabricated wiring connectors of size, ampacity rating, material, type, and class for application and service indicated. Comply with Project's installation requirements and as specified in Part 3 Article, "*Wire and Insulation Applications*".
- B. Split Bolt Connectors: Not acceptable.
- C. Solderless Pressure Connectors: High copper alloy terminal. May be used only for cable termination to equipment leads or terminals. Not approved for splicing.
- D. Spring Wire Connectors: Solderless spring type pressure connector with insulating covers for copper wire splices and taps. Use for conductor sizes 10 AWG and smaller.
- E. All wire connectors used in underground or exterior pull boxes shall be gel-filled twist connectors or a connector designed for damp and wet locations.
- F. Mechanical Connectors: Bolted type tin-plated; high conductivity copper alloy; spacer between conductors; beveled cable entrances.
- G. Compression (crimp) Connectors: Long barrel; seamless, tin-plated electrolytic high conductivity copper tubing, internally beveled barrel ends. Connector shall be clearly marked with the wire size and type and proper number and location of crimps.

- H. Heat shrinkable tubing shall meet the requirements of ANSI C119.1-1986 for buried connections to 90 degrees C and shall be material flame-retarded per IEEE 383 *Vertical Tray Flame Test*.
- I. Motor connection kits shall consist of heat-shrinkable, polymeric insulating material over the connection area and a high dielectric strength mastic to seal the ends against ingress of moisture and contamination. Motor connection kits shall accommodate a range of cable sizes for both in-line and stub-type configurations. Connection kits shall be independent of cable manufacturer's tolerances.
- J. Wire Nut Connectors:
 - 1. Wire nuts installed in wet locations, exterior, etc., shall be self-contained, waterproof and corrosion-proof units incorporating prefilled silicone grease to block out moisture and air.
 - 2. Connectors shall be UL listed and appropriately sized according to manufacturer's recommendation for the suitable wire sizes and voltage rating (600 volt minimum).
 - 3. Connector body shall have a color-coded outer shell.
 - 4. Connectors shall be as manufactured by King Technology or approved equal.

2.4 METAL CLAD (MC) CABLE AND CONNECTORS

- A. Cable shall meet or exceed the requirements of UL Standard 85, UL Standard 1063, and UL Standard 1569 for Type MC cable, Federal Specification A-A59544 *Vertical Cable Tray Flame Test* and the National Electrical Code. Cable shall be listed for use in UL 12, and 3 Hour Through-Penetration Firestop Systems.
- B. Cable shall be constructed with soft drawn copper, 600 volt, type THHN/THWN conductors rated 90°C dry/75°C wet, with a green insulated ground conductor. Only cables with conductor sizes 12 AWG and 10 AWG shall be permitted. Conductors shall be cabled together with a binder tape bearing a print legend that is wrapped around the assembly. An aluminum interlocked armor shall be applied over the assembly. Conductors shall be protected by an anti-short bushing at each termination.
- C. Multi-circuit MC cable is not permitted.
- D. Straight connectors shall be one-piece spring-steel, set screw design with nylon insulator. Provide ACB series, as manufactured by Crouse-Hinds, or approved equal.
- E. 45 and 90 degree connectors shall be die cast zinc, clamp type with insulated throat. Provide ACBXX45 or ACBXX90 series as manufactured by Crouse-Hinds, or approved equal.
- F. Cables shall be supported with appropriate hangers; tie wire will not be accepted.

2.5 CORDS

- A. Description: Continuous length of cable with locking blade type connector body at lower end as indicated on Drawings. Secure cable at both ends with wire type stainless steel cable grips to prevent transmission of tension directly to conductors or terminal screws.
- B. Junction Box: Furnished and installed flush with ceiling anchored to building structure for fastening of upper cord grip.

- C. Cable: Type SO 600 volt flexible cord with three #12 stranded wires.
- D. Connector Body: Single 120 volt, grounding receptacle of twistlock type that grips on cable insulation and is manufactured for use with wire cable grips. Furnish and install drop cords in length required for a receptacle height of 6 feet 8 inches above the finished floor.

2.6 INSULATING TAPE, PUTTY, RESIN AND SUPPORTS

- A. Tape: Provide plastic electrical insulating tape which is flame-retardant, cold and weather-resistant. Tape for use in areas subject to temperatures 30 degrees C to 105 degrees C, or where the tape will be subjected to an oil splash, tape shall have a minimum thickness of 8.5 mils, and shall consist of an oil-resistant acrylic adhesive.
- B. Materials: Provide all insulating materials for splices and connections such as glass and synthetic tapes, putties, resins, splice cases, or compositions of the type approved for the particular use, location, voltage and temperature and apply and install in an approved manner, all in accordance with the manufacturer's recommendations.
- C. Supports: Provide cable supports of the wedge type which firmly clamp each individual cable and tighten due to the cable weight.

PART 3. EXECUTION

3.1 EXAMINATION

- A. Examine raceways and building finishes to receive wires and cables for compliance with requirements for installation tolerances and other conditions affecting performance of wires and cables. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. By beginning work, the Contractor has accepted conditions and assumes responsibility for correcting unsuitable conditions encountered at no additional cost to the Owner.

3.2 PREPARATION

- A. Completely and thoroughly swab raceway before installing wire.

3.3 WIRE AND INSULATION APPLICATIONS

- A. No branch circuit wires smaller than #12 AWG shall be used unless otherwise indicated. Conductors shall be continuous from outlet to outlet and from terminal board to point of final termination and no splice shall be made except within outlet or junction boxes. All conductors shall be of the size indicated. All wires #8 AWG and larger shall be stranded.
- B. Control wiring shall not be less than #14 AWG and shall be color coded using colors impregnated into the insulation. All wiring, contacts, and terminal blocks shall be suitably tagged for ease in identification and tracing of circuits. Identification tags shall be engraved fiber or plastic type, subject to acceptance. Wires shall be numbered and coded, using Brady *Quicklabels*, or equal.

1. Wiring shall be tagged at terminations, in pull boxes, junction boxes, outlet boxes, panelboards, handholes, etc.
- C. All emergency wiring shall have the same color coding but shall clearly be identified as emergency in all outlets, fixtures, etc. All emergency wiring shall be installed in a dedicated conduit system.
- D. Switch leg wire shall be labeled with "S" tag.
- E. All control wiring shall be color coded with wires of colors different from those used to designate phase wires.
- F. Wiring for general 15 and 20 amp branch circuit work shall be as indicated on Drawing E00-01.
- G. Joints of #10 AWG and smaller shall be made with properly insulated solderless type pressure connectors. Where stranded conductors or multiple solid conductors are connected to terminals, solderless lugs manufactured by Thomas and Betts Company or equivalent shall be used.
- H. Joints of #8 AWG and larger in power and lighting circuits shall be of the type inserted into the conductor by means of a hand or hydraulic pressure tool. Connectors shall be *Brandy Hy-dent*, *T&B Sta-Kon*, or equivalent. Connectors for control wiring shall be *Burns Hy-Lug* or equivalent.
- I. All circuits for exterior electric work shall be #10 AWG (minimum) and contain an extra #10 AWG (minimum) copper ground conductor. All exterior wiring shall be installed in conduit as specified above, unless otherwise noted on the Drawings.
- J. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.
- K. Feeders Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
- L. Feeders below Slabs-on-Grade, and Underground: Type RHW-2, single conductors in raceway.
- M. Exposed Branch Circuits, Including in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- N. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type MC cable. Homeruns may be type MC cable to the source panelboard in electrical rooms when the remainder of the circuit is type MC.
- O. Branch Circuits below Slabs-on-Grade, and Underground: Type RHW-2, single conductors in raceway. Branch circuits may only be installed below slab on grade when required to reach floor boxes. Floor boxes on second and third floors are to be from a fire rated poke-through from floor below.
- P. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-nut, strain relief device at terminations to suit application.

3.4 INSTALLATION

- A. Install wires and cables as indicated, according to manufacturer's written instructions and NECA's *Standard of Installation*.
- B. Remove existing wires from raceway before pulling in new wires and cables.
- C. Pull Conductors: Use a UL-listed and 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. Completely and thoroughly swab conduit system before installing conductors.
- E. Install exposed cables, parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Division 26 Section, *Common Work Results for Electrical* and Division 26 Section, *Hangers and Supports*.
- G. Seal around cables penetrating fire-rated elements according to Division 26 Section 260528 *Electrical Firestopping*.
- H. Identify wires and cables according to Division 26 Section, *Electrical Identification*.
- I. Conductors installed in parallel shall be of equal lengths.
- J. Wiring at Outlets: Install with at least 12 inches (300 mm) of slack conductor at each outlet.
- K. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.
- L. The Contractor shall provide suitable installation equipment to prevent cutting and abrasion of conductor insulation. The Contractor shall use suitable cable guides, pulleys, and protective sleeving to prevent damage to cable during installation. Ropes used for pulling of wire and cable shall be made of polyethylene or other suitable non-metallic material. Pulling lines shall be attached to cable by means of either woven basket grips or pulling types attached directly to the conductor. Wire pulling lubricants, if used, shall conform to UL requirements applicable to the various insulation and raceway materials. The lubricants shall be certified by the manufacturer to be non-injurious to such insulation and materials.
- M. Each feeder cable shall be labeled at terminals and at all accessible points in equipment and in pull boxes. Each control wire shall be labeled at both ends. Labels shall be self-sticking wire markers.
- N. Riser cables shall have cable supports as required by Code.
- O. For rubber and plastic-covered wire and cable, pulling compound Ideal Yellow 77 may be used.

- P. Terminal lugs for wires #8 AWG and larger shall be T&B 54,000 Series or Burndy *HY-Dent*, compression type, unless noted otherwise. One-hole lugs for #4/0 AWG and smaller. Two-hole lugs for all sizes #250 kcmil AWG and larger.
- Q. Install wires and cables using braided rope larger than the cable being pulled to keep twists to a minimum.
- R. Install electrical cables, wires, and connectors as indicated in compliance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation", and in accordance with recognized industry practices.
- S. Coordinate cable and wire installation work with electrical raceway and equipment installation work, as necessary for proper interface.
- T. Conductors installed in runs within 6 inches of heating pipes or equipment shall be type A or A.
- U. No conductors shall be drawn into conduit until all work, which may cause cable damage, is completed.
- V. All wiring in fluorescent fixture channels, over boilers and breechings, over kitchen hoods, and in other high ambient temperature areas, shall be of types required by NEC.
- W. During installation, do not deform cable by improper bending, stretching, twisting, kinking, or pinching, nor do any other abusive handling. Any failure to observe these instructions will be detected and corrected during the demonstrations following completion of the installation. All cable runs shall contain S loops or other means to accommodate expansion or contraction as required. Cable bends will have a radius not less than the value recommended by the cable manufacturer. Cable connected to electronic equipment in the system shall be tagged to show its function and the location of its other end. All labels shall be of durable material and securely fastened to the cable.
- X. Wiring of different system voltages shall not be mixed at pull boxes enclosures, surface metal raceway, wiretrough, etc., unless a barrier (separator) is provided between the differing systems.

3.5 CONNECTIONS

- A. Conductor Splices: Keep to a minimum.
- B. Install splices and taps that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.
- C. Use splice and tap connectors compatible with conductor material.
- D. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer.
- E. 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 and UL 486B.

- F. Wire splices and taps shall be adequate to carry full current rating of wire.
- G. Splices and taps in wires up to #8 AWG shall be made with *Scotch-lok* or T&B PT Series or Ideal Wing Nut insulated electrical connectors. Wire nuts installed in wet location boxes shall be silicon gel-filled. For wires #8 AWG and larger, use copper solderless connectors covered with insulating molded body and then wrapped with electrical tape. Use twist-on wire connectors for connecting lighting fixtures and small motor leads up to #8 AWG wire.
- H. Conductors shall be continuous from outlet to outlet, and no splices shall be made except within outlet or junction boxes. Junction boxes may be utilized where required. Wire connectors of insulating material or solderless pressure connections, properly taped, shall be utilized for all splices in wiring.
- I. Splices in branch circuits and feeders shall be made where indicated or as required for the installation. All splices shall be accessible and made in enclosure approved for that purpose.
- J. For splices in branch circuits and feeders, provide connectors as follows:
 - 1. Wire Sizes #12 AWG to #10 AWG: Provide Ideal Model 74E or 76B or equivalent by T&B.
 - 2. Wire Sizes #8 AWG and Larger: Provide Ideal Model Series CP and T or equivalent by Burndy, O-Z, or T&B. All splices shall be enclosed in insulating molded thermoplastic, rubber, or rubber-like covers or shall be wrapped with Bishop No. 111 or equivalent insulating tape in accordance with the Manufacturer's directions.
- K. Thoroughly clean wiring prior to installing lugs or connectors.

3.6 IDENTIFICATION

- A. Interface with Other Work:
 - 1. Identify wire and cable using Thomas and Betts Type WM vinyl markers.
 - 2. Identify each phase and neutral conductor with its circuit number or other designation indicated on the Drawings in all junction, pull, terminal boxes, and cabinets.
- B. Provide identification tags on each conductor entering panel, switch, junction box, and pull box to identify conductor.
- C. Comply with the requirements of Division 26 Section, *Electrical Identification*.
- D. Feeder Identification: Securely fasten nonferrous identifying tags or pressure-sensitive labels to all cables, feeders, and power circuits in pull boxes, handholes, panelboards, and at termination of:
 - 1. Tags or labels shall be stamped or printed to correspond with markings on Contract Drawings or marked so that feeder or cable may be readily identified.
 - 2. If suspended type tags are provided, they shall be attached by approximately 55-pound test monofilament line or slip-free plastic cable lacing units.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent testing agency to perform field quality-control testing.
- B. Testing: On installation of wires and cables and before electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.3.2. Certify compliance with test parameters.
- C. Correct malfunctioning conductors and cables at Project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.
- D. Measure tightness of bolted connections and compare torque measurements with manufacturer's recommended values.
- E. Verify continuity of each branch circuit conductor.
- F. Tests: Feeder circuit insulation shall be tested after installation, and before connection to fixtures and appliance.
 - 1. Tests shall be performed with a 1,000-volt Megger insulation tester, and conductors shall test free from short-circuits and grounds.
 - 2. Conductors shall be tested phase-to-phase and phase-to-ground.
 - 3. Furnish the instruments, materials, and labor required. Perform the tests in the presence of the Owner's Representative.
 - 4. Actual test readings shall be recorded.
 - 5. Submit all test reports to the Architect/Engineer for approval.
- G. Demonstration: Subsequent to wire and cable hook-ups, energize circuit and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

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DIVISION 26 SECTION 26 05 20
ELECTRIC HEATING CABLES
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SECTION 26 05 20 - ELECTRIC HEATING CABLES

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 Section includes heating cables for the following applications:
 - 1. Heat tracing for freeze protection.

1.3. DEFINITIONS

- A. AWG: American Wire Gauge.
- B. C: Celsius.
- C. F: Fahrenheit.

1.4. SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Diagram power, signal, and control wiring and differentiate between manufacturer installed and field installed wiring.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements
- D. Maintenance Data: For electric heating cables to include in maintenance manuals specified in Division 0
- E. Warranties: Special warranties specified in this Section.

1.5. QUALITY ASSURANCE

- A. 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.

1.6. COORDINATION

- A. Coordinate layout and installation of electric heating cables and system components with other construction.
 - 1. Coordinate with Food Service Equipment installer for piping installed under Division 11.
 - 2. Coordinate with piping installer, for condensate piping provided under Division 23.

1.7. WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of electric heating cables that fail in materials or workmanship within specified warranty period.
- C. Warranty Period: Two years from date of Substantial Completion.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Accutron Heat Tracing Systems.
 - 2. Ari Industries.
 - 3. BICC Pyrotronax USA, Inc.
 - 4. Caloric, Inc.
 - 5. Chrono-Trax; Wiegard Industrial Division; Emerson Electric Company.
 - 6. Delta Therm Inc.
 - 7. Delta Therm Corp.

8. Easy Heat, Inc.
9. INDEECO.
10. Maxxon Corp.; Infloor Heating Systems Div.
11. Nelson Heat Tracing Systems.
12. Omega Engineering Inc.
13. Raychem Corporation.
14. Thermon Manufacturing Co.

2.2. ELECTRICAL HEAT TRACING FOR PIPELINES

- A. The self-regulating heater shall consist of two (2) 16 AWG nickel coated-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heater to be crossed over itself without overheating, to be used directly on plastic pipe, and to be cut to length in the field. The heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket.
- B. In order to provide energy conservation and to prevent overheating, the heater shall have a self-regulating factor of at least 90 percent. The self-regulating factor is defined as the percentage reduction, without thermostatic control, of the heater output going from 40 degrees F pipe temperature operation to 150 degrees F pipe temperature operation.
- C. The heater shall operate on line voltages of 120 volts without the use of transformers.
- D. The heater shall be sized according to this table. The required heater output rating is in watts per foot at 50 degrees F.

Pipe Size	Watts per foot
3 inch or less	5 watt
4 inch	5 watt
6 inch	8 watt
8 inch	2 strips - 5 watt
12 inch to 14 inch	2 strips - 8 watt

- E. Power connection, end seal, splice and tee kit components shall be applied in the field.

- F. The system shall be controlled by a thermostat set at 40 degrees F either directly or through an appropriate contactor.

2.3. DOMESTIC WATER PIPING FREEZE PROTECTION CONTROLS

- A. Heat trace cables providing freeze protection for water piping shall be controlled by an electronic outdoor thermostat.
- B. Outdoor thermostat shall utilize stainless steel sensor with 25 foot lead to sense pipe temperature, and shall have adjustable temperature range from 30 to 110 degrees Fahrenheit (-1 to 43 degrees Celsius).
- C. Thermostat switch shall be rated at 120VAC, 30 amperes.
- D. Thermostat shall have LED indicators for alarm, power, and heating cable status.
- E. Provide Raychem Digitrace EC-TS electronic thermostat, or approved equal by listed manufacturer.

2.4. FIRE SPRINKLER PIPING FREEZE PROTECTION CONTROLS

- A. Heat trace cables providing freeze protection for fire sprinkler piping shall be controlled by an electronic controller that is UL Listed for protection of fire sprinkler piping against freezing.
- B. Electric heat trace controllers shall control, monitor, and communicate alarms and data for one heating cable circuit.
- C. Electronic heat trace controllers shall have the following features:
 - 1. Modbus, BACnet and Ethernet communication module. Coordinate Modbus/BACnet module type with building management/ATC system installer and Division 23.
 - 2. Six character alpha numeric display.
 - 3. -40 degrees Fahrenheit to 140 degrees Fahrenheit (-40 degrees Celsius to 60 degrees Celsius) operation.
 - 4. Single or dual temperature sensor inputs to allow selection of one or eight control modes and programming of all temperature parameters.
 - 5. High and low temperature alarms.
 - 6. High temperature cut-out.
 - 7. Low current alarms.
 - 8. 30A rated electromechanical relay (EMR) output switch with device failure alarm.
 - 9. Ground fault alarm and trip.

10. Proportional ambient sensing control to maximize energy efficiency.
11. Minimum/Maximum temperature tracking
12. Auto-cycling to momentarily energize the circuit during periods of non-use to detect issues with the heat tracing circuit.

- D. Provide Raychem DigiTrace C910-485 heat trace controller, or approved equal by listed manufacturer.

2.5. ACCESSORIES

- A. Cable Installation Accessories: Tapes, cable ties, warning labels, end seals and splices, and installation clips.

PART 3. EXECUTION

3.1. EXAMINATION

- A. Examine surfaces and substrates to receive heating cables for compliance with requirements for installation, tolerances, and other conditions affecting performance.
 1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
 2. Ensure pipe testing is complete.
 3. Ensure surfaces and substrates are level and plumb.
- B. Test cables for electrical continuity before installing.
- C. Test cables for insulation resistance before installing.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. INSTALLATION

- A. Cut cable(s) to lengths required.
- B. Install heater to cold lead connections in accessible locations. Do not embed in concrete or plaster.
- C. Avoid crossing expansion, construction, or control joints with heating cables. Provide sufficient slack conductor in expansion loop.

- D. Provide labels for piping insulation/jacketing to identify the same as “electrically heat-traced”.

3.3. CONNECTIONS

- A. Electrical installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of wiring, conduit, and specialties.
- B. Connect heating cables and other components to wiring systems.
- C. Ground equipment:
 - 1. 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 and UL 486B.
- D. Connect heat trace controllers for fire sprinkler freeze protection to fire alarm systems required to transmit the following alarm conditions:
 - 1. Low pipe temperature.
 - 2. High pipe temperature.
 - 3. Loss of power.
 - 4. Ground fault trip.

3.4. FIELD QUALITY CONTROL

- A. Testing: Perform tests after installation but before application of coverings, such as insulation, plaster, or concrete.
 - 1. Test cables for electrical continuity before energizing.
 - 2. Test cables for insulation resistance before energizing. Remove cables if measured resistance is less than 10 megohms to ground.
 - 3. Test cables to verify heating and power input. Energize and measure voltage and current simultaneously.
- B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation.
- C. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5. ADJUSTING

- A. Set field adjustable thermostat ranges as indicated.

3.6. PROTECTION

- A. Protect installed heating cables, including leads, from damage prior to Substantial Completion.

END OF SECTION

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DIVISION 26 SECTION 26 05 26
GROUNDING AND BONDING
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SECTION 26 05 26 - GROUNDING AND BONDING

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. Bond each separately-derived system neutral to nearest grounding system.
- B. Bond together system neutrals; service equipment enclosures; exposed non-current carrying metal parts of electrical equipment; metal raceway systems; grounding conductor in raceways; receptacle ground connectors; and plumbing systems.

1.3 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 01 Specification Sections.
- B. Product Data for grounding rods, conductors, connectors and connection materials, and grounding fittings. Submit ground system manufacturer's recommended installation procedure for review.
- C. Qualification data for firms and persons specified in *Quality Assurance* Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
- D. Field tests and observation reports certified by the testing organization and indicating and interpreting the test reports for compliance with performance requirements.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: A *Nationally Recognized Testing Laboratory* (NRTL) as defined in OSHA Regulation 1910.7, or a full member company of the International Electrical Testing Association (NETA).
 - 1. Testing Agency Field Supervision: Use persons currently certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Comply with NFPA 70 - National Electrical Code.
- C. Comply with UL 467 - UL Standard for Safety Grounding and Bonding Equipment.

- D. Comply with ANSI/IEEE C2 - National Electrical Safety Code.
- E. Comply with ANSI/IEEE 32 - Requirements, terms and test procedures for neutral grounding devices.
- F. Comply with IEEE Standard 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
- G. Comply with ANSI C33.8.
- H. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 - 1. The Terms *Listed* and *Labeled*: As defined in the National Electrical Code, Article 100.
 - 2. Listing and Labeling Agency Qualifications: A *Nationally Recognized Testing Laboratory* (NRTL) as defined in OSHA Regulation 1910.7.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Erico Inc.; Electrical Products Group.
 - 2. Heary Brothers Lightning Protection Co.
 - 3. Ideal Industries, Inc.
 - 4. ILSCO.
 - 5. O-Z/Gedney Co.
 - 6. Raco, Inc.
 - 7. Thomas & Betts, Electrical.

2.2 GROUNDING AND BONDING PRODUCTS

- A. Governing Requirements: Where types, sizes, ratings, and quantities indicated are in excess of National Electrical Code (NEC) requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.

2.3 WIRE AND CABLE GROUNDING CONDUCTORS

- A. Comply with Division 26 Section 260519, *Conductors and Cables*. Conform to NEC Table 8, except as otherwise indicated, for conductor properties, including stranding.
- B. Equipment Grounding Conductors: Insulated with green color insulation, size as indicated on the Drawings, or as required by 2017 National Electrical Code (NEC) Table 250-122, whichever is larger.

- C. Grounding-Electrode Conductors: Stranded cable. Size as indicated on the Drawings, in the Specifications, or as required by 2017 National Electrical Code (NEC) Table 250-66, whichever is larger.
- D. Bare Copper Conductors: Conform to the following:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Assembly of Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.

2.4 MISCELLANEOUS CONDUCTORS

- A. Grounding Bus: Bare, annealed-copper bars of rectangular cross section, minimum size 1/2-inch x 2-inch.
- B. Braided Bonding Jumpers: Copper tape, braided No. 30 AWG bare copper wire, terminated with copper ferrules.
- C. Bonding Straps: Soft copper, 0.05 inch (1 mm) thick and 2 inches (50 mm) wide, unless otherwise indicated.

2.5 CONNECTOR PRODUCTS

- A. Mechanical Connectors
 - 1. The mechanical connector bodies shall be manufactured from high strength, high conductivity cast copper alloy material. Bolts, nuts, washers and lockwashers shall be made of silicon bronze and supplied as a part of the connector body and shall be of the two-bolt type.
 - 2. Split bolt connector types are NOT allowed unless indicated on the Drawings.
 - 3. The connectors shall meet or exceed UL 467 and be clearly marked with the catalog number, conductor size and manufacturer.
- B. Compression Connectors
 - 1. The compression connectors shall be manufactured from pure wrought copper. The conductivity of this material shall be no less than 99 percent by IACS Standards.
 - 2. The connectors shall meet or exceed the performance requirements of IEEE 837, latest revision.
 - 3. The installation of the connectors shall be made with a compression, tool and die system, as recommended by the manufacturer of the connectors.
 - 4. The connectors shall be clearly marked with the manufacturer, catalog number, conductor size and the required compression tool settings.
 - 5. Each connector shall be factory filled with an oxide-inhibiting compound.
- C. Exothermic Connections: Provide exothermic-weld kit selected per manufacturer's written instructions for specific types, sizes, and combinations of conductors and connected items.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Equipment Grounding Conductors: Comply with NEC Article 250 for types, sizes, and quantities of equipment grounding conductors, except where specific types, larger sizes, or more conductors than required by NEC are indicated.
1. Install Equipment Grounding Conductor (EGC) with circuit conductors for the items below in addition to those required by Code:
 - a. Feeder circuits.
 - b. Lighting branch circuits.
 - c. Receptacle branch circuits.
 - d. Single-phase motor or appliance branch circuits.
 - e. Three-phase motor or appliance branch circuits.
 - f. Flexible raceway runs.
 2. Computer Outlet Circuits: Install separate equipment grounding conductor in branch circuit runs from computer area power panels or power-distribution units.
 3. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.
 4. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 V and above, including air cleaners and heaters. Bond conductor to each unit and to air duct.
- B. Separately Derived Systems: Where NEC requires grounding, ground according to NEC Article 250.26.

3.2 INSTALLATION

- A. General: Ground electrical systems and equipment according to NEC requirements, except where Drawings or Specifications exceed NEC requirements.
- B. Grounding Conductors: Route along the shortest and straightest paths possible, except as otherwise indicated. Avoid constructing access or placing conductors where they may be subjected to strain, impact, or damage.
- C. Grounding shall satisfy requirements of the applicable publications. All exposed noncurrent-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in raceways, and grounded conductors of the wiring system shall be grounded.
- D. The grounded conductor (neutral) of the wiring system shall be connected to the system grounding conductor at a single place in the system by removable bonding jumpers, sized according to the applicable provisions of the National Electrical Code. The grounded conductor (neutral) connection to the grounding conductor (ground) shall be located in the enclosure for the system's overcurrent protection or where otherwise indicated on the Drawings or Specifications.

- E. Ground buses and neutral buses in all distribution panelboards, switchboards, panelboards, and those provided in any equipment shall be isolated except where required to be connected as specified above for the service entrance and in transformer terminal compartments.
- F. Equipment grounding conductors shall be extended from the ground bus in the distribution equipment to the receptacle, fixture or device lugs where they are provided. When not provided, they shall be connected to equipment enclosures. The connections shall be arranged such that removal of receptacle, the equipment grounding conductors, or ground jumpers from ground busing, shall not affect the system ground.
- G. Ground bus shall be provided as indicated on the Drawings or as necessary to provide termination for equipment grounding conductor. Non-current carrying metal parts of electric equipment shall be effectively grounded by bonding to the bus. The ground bus shall be bonded to both the system neutral and the service ground.
- H. Raceways shall not be considered as a grounding conductor. Each power, lighting, or control raceway shall have a separate equipment grounding conductor installed. Receptacles shall have a separate grounding pole.

3.3 CONNECTIONS

- A. General: Make connections so possibility of galvanic action or electric corrosion is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
 - 1. Use electroplated or hot-tin-coated materials to assure high conductivity and to make contact points closer in order of galvanic series.
 - 2. Make connections with clean, bare metal at points of contact.
- B. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections. Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
- C. Equipment Grounding Conductor (EGC) Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
- D. Non-Contact Metal Raceway Terminations: Where metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at both entrances and exits with grounding bushings and bare grounding conductors, except as otherwise indicated.
- E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. Where these requirements are not available, use those specified in UL 486A and UL 486B.

- F. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by manufacturer of connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

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DIVISION 26 SECTION 26 05 28
ELECTRICAL FIRESTOPPING
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SECTION 26 05 28 – ELECTRICAL FIRESTOPPING

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. Through-penetration firestopping in fire rated construction.
 - 2. Through-penetration smoke-stopping in smoke partitions.
- B. Related items: Raceway seals and manufactured electrical devices. Refer to Division 26 Section, "Raceways and Boxes".

1.3 REFERENCES

- A. Underwriters Laboratories
 - 1. UL Fire Resistance Directory
 - a. Through-penetration firestop devices (XHCR)
 - b. Fire resistance rating (PXUV)
 - c. Through-penetration firestop systems (XHEZ)
 - d. Fill, void or cavity material (XHHW)
- B. American Society for Testing and Materials Standards: ASTM E 814-88: Standard Test Method for Fire Tests of Through-Penetration Firestops.

1.4 DEFINITIONS

- A. Assembly: Particular arrangement of materials specific to given type of construction described or defined in referenced documents.
- B. Barriers: Time-rated fire walls, smoke barrier walls, time rated ceiling/floor assemblies and structural floors.
- C. Firestopping: Methods and materials applied in penetrations and unprotected openings to limit spread of heat, fire, gasses and smoke.

- D. Penetration: Opening or foreign material passing through or into barrier or structural floor such that full thickness of rated materials is not obtained.
- E. System: Specific products and applications classified and numbered by Underwriters Laboratories, Inc. to close specific barrier penetrations.
- F. Sleeve: Metal fabrication or pipe section extended through thickness of barrier and used to permanently guard penetration. Sleeves are described as part of penetrating system in other Sections and may or may not be required.

1.5 SYSTEM DESCRIPTION

A. Design Requirements

- 1. Fire-rated construction: Maintain barrier and structural floor fire resistance ratings including resistance to cold smoke at all penetrations, connections with other surfaces or types of construction, at separations required to permit building movement and sound or vibration absorption.
- 2. Smoke barrier construction: Maintain barrier and structural floor resistance to cold smoke at all penetrations, connections with other surfaces and types of construction and at all separations required to permit building movement and sound or vibration absorption.

1.6 SUBMITTALS

- A. Submit in accordance with Division 01, unless otherwise indicated.
- B. Product Data: Manufacturer's specifications and technical data including the following:
 - 1. Detailed specification of construction and fabrication.
 - 2. Manufacturer's installation instructions.
- C. Shop Drawings: Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, plus the following specific requirements:
 - 1. Details of each proposed assembly identifying intended products and applicable UL system number, or UL classified devices.
 - 2. Manufacturer or manufacturer's representative shall provide qualified engineering judgment and drawings relating to non-standard applications as needed.
- D. Manufacturer's submittals: Statement of qualifications.
- E. Applicators' qualifications statement: List past projects indicating required experience.

1.7 QUALITY ASSURANCE

- A. Installer's qualifications: Firm experienced in installation or application of systems similar in complexity to those required for this project, plus the following:

1. Acceptable to or licensed by manufacturer, State or local authority where applicable.
2. At least 2 years' experience with systems.
3. Successfully completed at least 5 comparable scale projects using this system.

B. Local and State regulatory requirements: Submit forms or acceptance for proposed assemblies not conforming to specific UL Firestop System numbers, or UL classified devices.

C. Materials shall have been tested to provide fire rating at least equal to that of the construction.

D. Manufacturer shall be a member of the International Firestop Council (IFC).

1.8 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:

1. Deliver products in original unopened packaging with legible manufacturer's identification.
2. Coordinate delivery with scheduled installation date, allow minimum storage at site.

B. Storage and protection: Store materials in a clean, dry, ventilated location. Protect from soiling, abuse, moisture and freezing when required. Follow manufacturer's instructions.

1.9 PROJECT CONDITIONS

A. Existing conditions:

1. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.
2. Proceed with installation only after preparations of the substrate and supporting brackets have been installed.

B. Environmental requirements:

1. Furnish adequate ventilation if using solvent.
2. Furnish forced air ventilation during installation if required by manufacturer.
3. Keep flammable materials away from sparks or flame.
4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.

1.10 GUARANTEE

A. Submit copies of written guarantee agreeing to repair or replace joint sealers which fall in joint adhesion, extrusion resistance, migration resistance, or general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated. The guarantee period shall be two years from date of substantial completion unless otherwise noted.

PART 2. PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
1. Hilti.
 2. 3M
 3. Nelson.

2.2 THROUGH-PENETRATION FIRESTOPPING OF FIRE-RATED CONSTRUCTION

- A. Systems of devices listed in the UL Fire Resistance Directory under categories X1, CR and X1EZ may be used, providing that it conforms to the construction type, penetration type, annular space requirements and fire rating involved in each separate instance, and that the system be symmetrical for wall applications. Systems or devices must be asbestos-free.
1. Additional requirements: Withstand the passage of cold smoke either as an inherent property of the system, or by the use of a separate product included as part of the UL system or device, and designed to perform this function.
 2. Acceptable manufacturers and products.
 - a. Those listed in the UL Fire Resistance directory for the UL System involved and as further defined in the "System and Applications Schedule" in Part 3 of this Section.
 - b. All firestopping products must be from a single manufacturer.

2.3 SMOKE-STOPPING AT SMOKE PARTITIONS

- A. Through-penetration smoke-stopping: Any system complying with the requirements for through-penetration firestopping in fire-rated construction, as specified in "The Systems and Applications Schedule" in Part 3 of this Section, is acceptable, provided that the system includes the specified smoke seal or will provide a smoke seal. The length of time of the fire resistance may be disregarded.

2.4 ACCESSORIES

- A. Intumescent cavity materials: As classified under category XHHW in the UL Fire Resistance Directory.
- B. Forming materials: As classified under category XHKU in the UL Fire Resistance Directory.
- C. Sleeves: Minimum 24 MSG galvanized steel, 12-inch diameter or smaller steel pipe. Sleeve shall project ½-inch from each surface of the floor/wall. Size as recommended by firestop manufacturer.

PART 3. EXECUTION

3.1 EXAMINATION

- A. Verification of conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.
 - 1. Verify barrier penetrations are properly sized and in suitable condition for application of materials.
 - 2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean surfaces to be in contact with penetration seal materials of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.

3.3 INSTALLATION

- A. Install penetration seal materials in accordance with printed instructions of the UL Fire Resistance Directory and in accordance with manufacturer's instruction.
- B. Seal holes or voids made by penetrations to ensure an effective smoke barrier.
- C. Protect materials from damage on surfaces subject to damage.
- D. When large openings are created in walls or floors to permit installation of conduits, cable tray, or other items, close unused portions of opening with fire stopping materials tested for the application.
- E. Install smoke stopping as specified for fire stopping.
- F. Provide sleeves the full thickness of the assembly being penetrated and cut sleeves to a length of 1-inch more than the over-all thickness of the penetration, or as recommended by the firestop manufacturer.

3.4 FIELD QUALITY CONTROL

- A. Examine penetration sealed areas to ensure proper installation before concealing or enclosing areas.
- B. Keep areas of work accessible until inspection by applicable code authorities.
- C. Allow for this section patching and repairing of firestopping caused by cutting or penetration by other trades.

3.5 ADJUSTING AND CLEANING

- A. Clean up spills of liquid components.
- B. Neatly cut and trim materials as required.

- C. Remove equipment, materials and debris, leaving area in undamaged, clean condition.

3.6 SYSTEMS AND APPLICATION SCHEDULES*

PENETRATING ITEM	CONCRETE	GYPSUM	WOOD FLOOR/CEILING
Metal Pipe	CAJ1001 CP25S/L, CP25N/S CAJ1006 CS-195+, FS-195+ CAJ1007 FS-195+, 1-inch& 2-inch Wide CAJ1009 2000, 2000+, 2003 CAJ1010 2000, 2000+, 2003 CAJ1012 2000, 2000+, 2003 CAJ1013 2000, 2000+, 2003 CAJ1014 2000, 2000+, 2003 CAJ1015 2000, 2000+, 2003 CAJ1017 FD 150 CAJ1021 FD 150 CAJ1027 MPS-2+ CAJ1044 CP 25WB+ CAJ1052 CP 25S/L, CP 25N/S CAJ1058 2000, 2000+, 2003 CAJ1060 2000, 2000+, 2003 CAJ1063 2000, 2000+, 2003 CAJ1066 CP 25N/S, CP 25S/L, CP 25WB+ CAJ1091 CP 25N/S, CP 25S/L, CP 25WB+ CAJ1092 CP 25WB+ CAJ1112 FS-195+ CAJ1160 CP 25S/L, CP 25N/S CAJ1175 CP 25WB+ CAJ1176 CP 25WB+ CAJ1188 2000+ CBJ1020 CS-195+, FS-195+ CBJ1021 CS-195+, MPS-2+ CBJ1031 2001 CBJ1032 2001 FA1002 CP 25WB+ WJ1010 CP 25WB+ WJ1023 2000+	WL1001 CP 25 WL1002 FS-195+ WL1003 CP 25WB+, CP 25N/S WL1008 2000+ WL1009 2000+ WL1010 2000+ WL1016 CP 25WB+ WL1017 CP 25WB+, CP 25N/S WL1032 CP 25WB+, CP 25N/S WL1036 FD 150 WL1037 CS-195+, FS-195+ WL1067 CP 25N/S WL1073 CP 25WB+ WL1080 MPS-2+ WL1082 2000+	FC1002 CP 25 FC1003 2000, 2000+, 2003 FC1006 CP 25WB+
Non-Metallic	CAJ2001 FS-195+, 1-inch& 2-inch WIDE, PPD'S CAJ2002 FS-195+ CAJ2003 CS-195+, FS-195+ CAJ2005 FS-195+ CAJ2006 FS-195+ CAJ2003 FS-195+ CAJ2019 2000, 2000+, 2003 CAJ2027 FS-195+, CP 25N/S, CP 25S/L, CP 25WB+ CAJ2028 FS-195, MPS-2+ CAJ2029 FS-195+, PPD'S CAJ2030 CS-195+, FS-195+ CAJ2040 FS-195+, CP 25WB+ CAJ2044 FS-195+, CP 25N/S, CP 25S/L, CP 25WB+ CAJ2090 FS-195+	WL2002 FS-195+, PPD'S WL2003 FS-195+ WL2004 FS-195+ WL2005 FS-195+ 4' WIDE WL2006 FS-195+ WL2013 FS-195+ WL2031 CS-195+, FS-195+ WL2032 CS-195+, FS-195+ WL2033 FS-195+ WL2073 FS-195+ 1-inch WIDE	FC2002 FS-195+, PPD'S FC2007 FS-195+, PPD'S FC2008 FS-195+ FC2009 FS-195+, PPD'S FC2024 FS-195+ FC2026 FS-195+ FC2028 FS-195+, 1' & 2-inch WIDE, PPD'S

PENETRATING ITEM	CONCRETE	GYPSUM	WOOD FLOOR/CEILING
	CAJ2177 FS-195+, PPD'S FA2001 FS-195+, PPD'S FS2002 CS-195+, FS-195+, MPS-2+, PPD'S FA2011 FS-195+ WJ2012 FS-195+ 1-inch WIDE		
Insulated Cable	CAJ3001 CP 25N/S, CP 25S/L CAJ3005 CS 195+, FS-195+ CAJ3007 2001 CAJ3009 2000, 2000+, 2003 CAJ3010 2000, 2000+, 2003 CAJ3011 2001 CAJ3014 FD 150 CAJ3015 FD 150 CAJ3021 MPS-2+ CAJ3029 2000, 2000+, 2003 CAJ3030 CP 25WB+ CAJ3031 CP 25N/S, CP 25S/L CAJ3041 2000, 2000+, 2003 CAJ3044 CS-195+, FS-195+ CAJ3058 FS-195+, MPS-2+ CAJ3071 CP 25N/S, CP 25S/L CAJ3074 CP 25N/S, CP 25S/L CAJ3075 2001 CAJ3080 CP 25WB+ CBJ3016 CS-195+, FS-195+ CBJ3017 CS-195+, MPS-2+ FA3001 CP 25WB+ FB3004 CS-195+, MP WJ3015 2001 WJ3016 2001	WL3001 CP 25, MPS-2+ WL3008 2000+ WL3009 2000+ WL3015 CP 25WB+, CP 25N/S WL3022 2000+ WL3030 FS-195+ WL3031 MPS-2+ WL3032 CP 25WB+ WL3041 2000+ WL3051 CP 25N/S WL3056 CP25N/S WL3062 CP 25WB+	FC3001 CP 25S/L, CP 25N/S FC3002 2000+ FC3003 2000, 2000+, 20003 FC3007 CP 25WB+, MPS-2+ FC3008
Mixed Penetrating Items Combos	CAJ8001 CS-195+ FS-195+ CAJ8003 2000, 2000+, 20003 CAJ8004 2000, 2000+, 20003 CAJ8006 2001 CAJ8013 FS-195+, CP 25 CBJ8004 CS-195+, FS-195+ CP 8005 CS-195+, MPS-2+ CP 8008 2001 FA 8001 FS-195+ CP 25WB+	WL8002 CS-195+, FS-195+	

* Underwriters Laboratories, Inc., Fire Resistance Directory.

END OF SECTION

DIVISION 26 SECTION 26 05 29
HANGERS AND SUPPORTS
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SECTION 26 05 29 – HANGERS AND SUPPORTS

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.
- B. Requirements of the following Division 26 Sections apply to this Section:
 - 1. “Common Work Results for Electrical” for general installation requirements.
 - 2. “Electrical Firestopping” for requirements for firestopping at sleeves through walls and floors that are fire barriers.

1.2 SUMMARY

- A. This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.
- B. Provide equipment supports consisting of platforms, curbs, concrete pads, gratings, cradles, structural members, hangers, rods, racks, and incidental materials.
- C. Provide all labor, supervision, and fabrication. Design and construct supporting structures of strength to safely withstand stresses to which they may be subjected and to properly distribute the load and impact over building areas. Provide all engineering and fabrication as required for installation of support system.
- D. Provide hangers, clamps, anchors, inserts, supports, supplementary steel framing, and hardware of the proper size and load capacity to support electrical equipment and raceways, whether indicated on the drawings or not.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with conditions of Contract and Division 01 Specification Sections.
- B. Submit samples for each type of product specified.
- C. Submit for review, shop/assembly drawings and layout drawings of curbs and equipment supports for major items of equipment.
- D. Submit structural calculations for approval. Calculations include stress and deflection analysis. Submit design criteria and selection calculation.

- E. Supporting devices and fastening methods shall be subject to the review and approval of the Structural Engineer.

1.4 QUALITY ASSURANCE

- A. Electrical Component Standard: Components and installation shall comply with NFPA 70 *National Electrical Code*.
- B. Electrical components shall be listed and labeled by UL, ETL, CSA, or other approved, nationally recognized testing and listing agency that provides third-party Certification follow-up services.
- C. Installation Standard: Installation shall meet or exceed the National Electrical Contractors Association (NECA) Standard of Installation.
- D. Manufacturer's Qualifications:
 - 1. The Manufacturer shall not have had less than ten years' experience in manufacturing Strut Support Systems.
 - 2. The Manufacturer must certify in writing all components supplied have been produced in accordance with an established quality assurance program.
- E. Installer's Qualifications:
 - 1. Installer must be a factory-trained manufacturer's authorized representative/installer with not less than five years experience in the installation of Strut Support Systems of this size and conformation.
 - 2. All Strut Support System components must be supplied by a single manufacturer.
- F. Standards:
 - 1. Work shall meet the requirements of the following standards:
 - a. Federal, State and Local Codes.
 - b. American Iron and Steel Institute (AISI) Specification for the Design of Cold-Formed Steel Structural Members - August 19, 1986 Edition, December 11, 1989 Addendum.
 - c. American Society for Testing and Materials (ASTM).
 - d. Underwriters Laboratories (UL).
 - e. National Electrical Code (NEC).

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. All material is to be delivered to the work site in original factory packaging to avoid damage to the finish.
- B. Upon delivery to the work site, all components shall be protected from the elements by a shelter or other covering.

1.6 GUARANTEE

- A. Separate guarantees shall be issued from the erector and manufacturer, valid for a period of one year against any defects that may arise from the installation or manufacture of the Strut Support System components.

PART 2. PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
 - 1. Slotted Metal Angle and U-Channel Systems:
 - a. American Electric, Kindorf
 - b. Alstrut
 - c. Unistrut Diversified Products
 - d. Power-Strut
 - e. Thomas & Betts

2.2 COATINGS

- A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion-resistance using approved alternative treatment, finish, or inherent material characteristic. All products shall be hot-dip galvanized.

2.3 MANUFACTURED SUPPORTING DEVICES

- A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.
- B. Fasteners: Types, materials, and construction features, as follows:
 - 1. Expansion Anchors - Carbon steel wedge or sleeve type.
 - 2. Toggle Bolts - All steel springhead type.
 - 3. Power-Driven Threaded Studs - Heat-treated steel, designed specifically for the intended application.
- C. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for non-armored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.

- U- Channel Systems: Sixteen-gauge channels with 9/16-inch-diameter holes at a minimum of eight inches on center in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacturer.
- D. Concrete Equipment Pads:
 - 1. Refer to Division 26 Section 260500, *Common Work Results for Electrical* for installation requirements.
- E. Floor-Mounted Stands: Construct with structural steel members or steel pipe and fasten with flanges bolted to the floor.
- F. Ceiling Suspended Platforms: Construct with steel hangers. Brace and fasten to building structure.
- G. Wall-Mounted Platforms: Construct with steel brackets.

2.4 ANCHOR METHODS

- A. Hollow Masonry: Toggle bolts or plastic conical type expansion anchors.
- B. Solid Masonry: Lead expansion anchors or preset inserts.
- C. Metal Surfaces: Machine screws, bolts, or welded studs.
- D. Wood Surfaces: Wood screws.
- E. Concrete Surfaces: Self-drilling anchors or power-driven studs (non-seismic zones).
- F. Existing Concrete: Expansion anchor fasteners.

2.5 VIBRATION ISOLATION MOUNT TYPES

- A. Type DNP (Double Neoprene Pad)
 - 1. Neoprene pads isolators shall be formed by two layers of 1/4-inch to 1/16-inch thick ribbed or waffled neoprene, separated by a stainless steel or aluminum plate. Layers shall be permanently adhered together. Pads shall be sized so that they will be loaded within the manufacturer's recommended range.
 - 2. Type DNP isolators shall be formed from one of the following products or approved equal:
 - a. Type NR: Amber/Booth.
 - b. Type Korpad: Korfund Dynamics.
 - c. Type WSW: Mason Industries.
 - d. Type NPS: Peabody Noise Control.
 - e. Series Shear Flex: Vibration Mountings and Control.

PART 3. EXECUTION

3.1 EXAMINATION

- A. The installer shall inspect the work area prior to installation. If work area conditions are unsatisfactory, installation shall not proceed until satisfactory corrections are completed.

3.2 INSTALLATION

- A. Installation shall be accomplished by a fully trained manufacturer-authorized installer.
- B. Set Strut System components into final position true to line, level and plumb, in accordance with approved Shop Drawings.
- C. Anchor material firmly in place. Tighten all connections to their recommended torques.
- D. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.
- E. Coordinate with the building structural system and with other electrical installation.
- F. Raceway Supports: Comply with the NEC and the following requirements:
 - 1. Conform to manufacturer's recommendations for selection and installation of supports.
 - 2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 pounds, provide additional strength unless there is a minimum of 200 pounds safety allowance in the strength of each support.
 - 3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
 - 4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
 - 5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/2-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
 - 6. Space supports for raceways in accordance with Table I of this Section. Space supports for raceway types not covered by the above in accordance with NEC.
 - 7. Support exposed and concealed raceway within one foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminations are not made with chase nipples or threadless box connectors.
 - a. For vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminations.
- G. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting disconnects, light fixtures, and other devices.

- H. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to the raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.
- I. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including, but not limited to conduits, raceways, boxes, disconnect switches, and control components in accordance with the following:
1. Fasten by means of toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures.
 2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4-inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
 3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration-and shock-resistant fasteners for attachment to concrete slabs.
 4. Concrete (Existing): Double-plated expander type anchors, Phillips Hilti, or approved equivalent. Loads shall not exceed 1/4 of tested pullout (or shear) strength.
 5. Precast Concrete Plank: Drill hole through plank; bolt hanger rod to 4" x 4" x 1/8" steel plate on top of plank.
- J. Tests: Test pull-out resistance of one of each type, size, and anchorage material for the following fastener types:
1. Expansion anchors.
 2. Toggle bolts.
 3. Power-driven threaded studs.
- K. Provide all jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the structural Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener. If fastening fails test, revise all similar fastener installations and retest until satisfactory results are achieved.
- L. General Supporting Installations:
1. Provide appropriate concrete anchors for hanger rods. Rods shall be screwed into or extended through frame construction (with washer and nut). Supports shall secure conduit in place, and shall prevent vibration, provide for expansion and contraction and shall make neat appearance. Strap hangers or chains are not permitted.
 2. Electrical raceways (conduit and EMT) 1-1/2-inches and smaller shall be secured with 1-hole malleable iron straps or brackets to walls. Trapeze supports shall be used for groups or parallel raceways with raceways secured to trapeze with approved clamps. Individual runs of raceways 2-inches and larger shall be supported by Clevis type hangers.
 3. Provide all steel supports including roof curbs for all equipment provided under this Section.
 4. Electrical raceway supports to be spaced on the following maximum centers, unless otherwise required by the NEC:

- a. 3/4-inch to 1-inch conduit - 8 feet
 - b. 1-1/4-inch and larger conduit - 10 feet
5. Provide additional hangers or steel members to distribute the load among two or more structural members when required or directed.
 6. Drilling of new concrete slabs will not be permitted. Anchors and inserts shall be cast in the concrete slabs.

M. Locations:

1. Anchor bolts, sleeves, inserts, hangers, and supports required for the electrical work shall be furnished and installed under Division 26.
2. Coordinate with other trades the location of anchors, sleeves, inserts, and supports and ensure that they are properly installed.
3. Openings and sleeves shall be set true to line, level, plumb, and position and shall be so maintained during construction. Where sleeves and openings are provided in poured concrete, inspect same during and after concrete is poured to ensure proper position and correct any deviation.

N. Hangers and Supports:

1. Provide hangers, angles, channels, and other supports required by field conditions to install items of electrical equipment. Design of supports and methods of fastening to building structure shall be acceptable to the Owner.
2. Use of power-actuated fasteners and devices is permitted in the vertical surfaces of the building only with the following requirements:
 - a. For fastening conduits 1-1/4-inch and smaller and lighting fixtures 50 lbs or less.
 - b. Load capacity per manufacturers' recommendations.
 - c. Fasteners shall be located in the thickest part of the slab.
 - d. Devices shall comply with OSHA requirements.
3. Use of lead shield expansion anchors is not permitted.
4. No electrical items shall rest on, or depend for support on suspended ceiling media (tiles, lath, plaster, spline, etc.).
5. In suspended ceilings, support conduits directly from structural slabs, decks (or framing members). Do not support conduits on ceiling suspension members.
6. Support surface or pendant lighting fixtures:
 - a. From an outlet box by means of an interposed metal strap, where weight is less than 5 lbs.
 - b. From an outlet box by means of a hickey or other direct threaded connection, where weight is from 5 to 50 lbs.
 - c. Directly from structural slab, deck or framing member, where weight exceeds 50 lbs.
7. In addition to the above, provide cushioned, swivel type hangers with appropriate outlet boxes for pendant fixtures in mechanical areas. Such hangers shall have a support rating at least twice that of the load supported.

8. Support recessed lighting fixtures directly from structural slab, deck, or framing members. Refer to Division 26 Section 265100, *Lighting* for additional installation requirements.
 9. Provide weight-distribution facilities, where required so as not to exceed the load bearing capabilities of floor or walls that bear the weight of, or support, electrical items.
 10. For point-of-attachment weight of 100 lbs. or less, fasten items as follows:
 - a. On wood, use wood screws.
 - b. On concrete and solid masonry that is already in place, use self-drilling concrete anchors or expansion bolt and couplings.
 - c. On hollow construction, use toggle bolts.
 - d. On structural steel, use beam clamps.
 11. For point-of-attachment weights from 100 lbs. to 300 lbs., provide supports as follows:
 - a. At cast-in-place concrete slabs, use concrete inserts in bottom of slab, with 8 lip-through steel rods set transverse to the reinforcing steel.
 - b. At concrete slab already in place, uses 16-inches x 8-inches x ½-inch steel plates at the top of the slab, with through-bolts welded in place. The plates shall be chased in and grouted flush, where no fill is to be applied.
 12. For point-of-attachment weights over 300 lbs., provide supports as follows: At cast-in-place concrete slabs, uses 16-inch x 8-inch x ½-inch steel plate, with through bolts welded in place. Top of the plate shall be 1-1/2-inches below the top of the slab or on top of the slab where a fill slab is to be installed.
 13. Hangers and supports shall be hot dipped galvanized, unless noted otherwise.
 14. Equipment shall not be held in place by its own dead weight. Provide base anchor fasteners in each case.
 15. Trapeze type hangers may be used where several conduits are to be installed at the same elevation. The spacing of such trapeze hangers shall be in accordance with the NEC for the smallest conduit in the run.
 16. Vertical conduits shall be supported by heavy wrought iron clamps or collars anchored to construction at each floor.
- O. Inserts:
1. Inserts for suspended items in poured concrete construction shall be malleable-iron concrete inserts, adjustable type with insert nut. Items manufactured by Barrett, Crawford, Elcen, or Grinnell shall be used where applicable.
 2. Inserts for surface-mounted items shall be suitable for the composition of the slab, wall, or structure on which installation is to be made.
- P. Spacing For Raceway Supports

TABLE I: SPACING FOR RACEWAY SUPPORTS				
Raceway Size (Inches)	No. of Conductors in Run	Location	RNC & IMC (Ft.)	EMT (Ft.)

		HORIZONTAL RUNS		
1/2, 3/4	1 or 2	Flat ceiling or wall.	5	5
1/2, 3/4	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	7	7
1/2, 3/4	3 or more	Any location.	7	7
1/2 - 1	3 or more	Any location.		
1 & larger	1 or 2	Flat ceiling or wall.	6	6
1 & larger	1 or more	Where it is difficult to provide supports except at intervals fixed by the building construction.	10	10
1 & larger	3 or more	Any location.	10	10
Any	---	Concealed.	10	10
		VERTICAL RUNS		
1/2, 3/4	---	Exposed.	7	7
1, 1-1/4	---	Exposed.	8	8
1-1/2 & larger	---	Exposed.	10	10
Up to 2	---	Shaftway.	14	10
2-1/2	---	Shaftway.	16	10
3 & larger	---	Shaftway.	20	10
Any	---	Concealed.	10	10
Abbreviations.	EMT	Electrical Metallic Tubing		
	IMC	Intermediate Metallic Conduit		
	RNC	Rigid Nonmetallic Conduit		
	RGS	Rigid Galvanized Steel		

3.3 CLEANUP

- A. Upon completion of this Section of work, remove all protective wraps and debris. Repair any damage due to installation of this section of work.

3.4 PROTECTION

- A. During installation, protect this work from damage.
- B. Upon completion of this scope of work, it shall become the responsibility of the General Contractor to protect this work from damage during the remainder of construction on the project and until substantial completion.

END OF SECTION

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DIVISION 26 SECTION 26 05 33
RACEWAYS AND BOXES
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SECTION 26 05 33 - RACEWAYS AND BOXES

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 Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1. Raceways include the following:

- a. EMT.
- b. FMC.
- c. IMC.
- d. LFMC.
- e. PVC.
- f. RGS.
- g. RMC.
- h. RNC.
- i. Wireways.

2. Boxes, enclosures, and cabinets include the following:

- a. Device boxes.
- b. Outlet boxes.
- c. Pull and junction boxes.
- d. Cabinets and hinged cover enclosures.

3. Miscellaneous Products include the following:

- a. Expansion/deflection fittings.
- b. Bushings.

- B. Related Sections include the following:

1. Division 26 Section 260528, *Electrical Firestopping* for requirements for firestopping at penetrations through walls and floors that are fire barriers.
2. Division 26 Section 260529, *Hangers and Supports* for raceways and box supports.
3. Division 26 Section 262726, *Wiring Devices* for devices installed in boxes.

1.3 DEFINITIONS

- A. EMT: Electrical Metallic Tubing.
- B. FMC: Flexible Metal Conduit.
- C. IMC: Intermediate Metal Conduit.
- D. LFMC: Liquidtight Flexible Metal Conduit.
- E. PVC: Rigid Polyvinyl Chloride Conduit.
- F. RGS: Rigid Galvanized Steel Conduit.
- G. RMC: Rigid Metal Conduit.
- H. RNC: Rigid Nonmetallic Conduit.

1.4 SUBMITTALS

- A. Product Data: For raceways, boxes, wireways, fittings, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: Include layout drawings showing components and wiring for nonstandard boxes, enclosures, and cabinets.

1.5 QUALITY ASSURANCE

- A. Listing and Labeling: Provide raceways and boxes specified in this Section that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100
 - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in CMAA Regulation 1910.7.
- B. Comply with NECA's "Standard of Installation" and NECA 101 "Recommended Practice for Installing Steel Conduits".
- C. Comply with NFPA 70

1.6 TERMINATION

- A. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access.
- B. Verify routing and termination locations of conduits and boxes prior to rough-in.
- C. Conduit routing shown on Drawings is only approximate and diagrammatic. Route conduits as required for a complete conduit and wiring system.

- D. Coordinate installation of outlet boxes, mounting heights, orientation, and locations of outlets.
- E. Coordinate mounting heights and locations of outlet boxes thoroughly with approved casework shop drawings.

1.7 PROJECT RECORD DOCUMENTS

- A. Accurately record routing of all concealed conduits. Record actual routing of all exposed conduits/larger than 1 inch. Indicate actual locations and mounting heights of outlet boxes, pull and junction boxes, branch circuits, arrangements, etc.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Metal Conduit and Tubing:

- a. Allied Tube & Conduit Corporation.
- b. Anamet, Inc.; Anaconda Metal Hose.
- c. AFC/Monogram Company.
- d. Carol Cable Co., Inc.
- e. Cole-Flex Corp.
- f. Electri-Flex Co.
- g. Flexcon, Inc.; Coleman Cable Systems, Inc.
- h. Grinnell Co.; Allied Tube and Conduit Div.
- i. Monogram Co.; AFC.
- j. Spiraduct, Inc.
- k. Triangl PWC, Inc.
- l. Wheatland Tube Co.

2. Nonmetallic Conduit and Tubing:

- a. Anamet, Inc.; Anaconda Metal Hose.
- b. Aruco Corp.
- c. Breeze-Illinois, Inc.
- d. Cantex Industries; Harsco Corp.
- e. Certainteed Corp.; Pipe & Plastics Group.
- f. Cole-Flex Corp.
- g. Condux International; Electrical Products.
- h. Electri-Flex Co.
- i. George-Ingraham Corp.
- j. Hubbell, Inc.; Raco, Inc.
- k. Lamson & Sessions; Carlon Electrical Products.
- l. R&G Sloan Manufacturing Co., Inc.

- m. Spiraduct, Inc.
 - n. Thomas & Betts Corp.
3. Conduit Bodies and Fittings:
- a. American Electric; Construction Materials Group.
 - b. Crouse-Hinds; Div. of Cooper Industries.
 - c. Emerson Electric Co.; Appleton Electric Co.
 - d. Hubbell, Inc.; Killark Electric Manufacturing Co.
 - e. Lamson & Sessions; Carlon Electrical Products.
 - f. O-Z/Gedney; Unit of General Signal.
 - g. Scott Fetzer Co.; Adalet-PLM.
 - h. Spring City Electrical Manufacturing Co.
 - i. Thomas & Betts Corporation.
4. Metal Wireways:
- a. Hoffman Engineering Co.
 - b. Keystone/Rees, Inc.
 - c. Square D Co.
5. Nonmetallic Wireways:
- a. Hoffman Engineering Co.
 - b. Lamson & Sessions; Carlon Electrical Products.
 - c. Wiremold Co.
 - d. Hubbell
6. Boxes, Enclosures, and Cabinets:
- a. American Electric FL Industries.
 - b. Butler Manufacturing Co.; Walker Division.
 - c. Crouse-Hinds; Div. of Cooper Industries.
 - d. Electric Panelboard Co., Inc.
 - e. Erickson Electrical Equipment Co.
 - f. Hoffman Engineering Co.; Federal-Hoffman, Inc.
 - g. Hubbell Inc.; Killark Electric Manufacturing Co.
 - h. Hubbell Inc.; Raco, Inc.
 - i. Lamson & Sessions; Carlon Electrical Products.
 - j. O-Z/Gedney; Unit of General Signal.
 - k. Parker Electrical Manufacturing Co.
 - l. Robroy Industries, Inc.; Electrical Division.
Scott Fetzer Co.; Adalet-PLM.
 - n. Spring City Electrical Manufacturing Co.
 - o. Thomas & Betts Corp.
 - j. Woodhead Industries, Inc.; Daniel Woodhead Co.

2.2 METAL CONDUIT AND TUBING

- A. Rigid Galvanized Steel Conduit: ANSI C80.1 and UL 6.
- B. IMC: ANSI C80.6.
- C. Plastic-Coated Steel Conduit and Fittings: NEMA RN 1.
- D. Plastic-Coated IMC and Fittings: NEMA RN 1.
- E. EMT and Fittings: ANSI C80.3, galvanized tubing.
 - 1. Fittings: Compression type, NEMA FB1.
- F. FMC: Zinc-coated steel.
- G. LFMC: Flexible steel conduit with PVC jacket.
- H. Fittings: NEMA FB 1; compatible with conduit/tubing materials.

2.3 NONMETALLIC CONDUIT AND TUBING

- A. PVC: NEMA TC 2, Schedule 40 or 80.
- B. PVC Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.

2.4 METAL WIREWAYS

- A. Material: Sheet metal sized and shaped as indicated.
- B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- C. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.
- D. Wireway Covers: Screw-cover type.
- E. Finish: Manufacturer's standard enamel finish.

2.5 OUTLET AND DEVICE BOXES

- A. Sheet Metal Boxes: NEMA OS 1, galvanized flat-rolled sheet steel.
- B. Cast-Metal Boxes: NEMA FB 1, Type FD, cast box, deep type, with gasketed cover, and threaded hubs.

- C. Outlet Box Accessories: Provide outlet box accessories as required for each installation, including corrosion-resistant screws, mounting brackets, wallboard hangers, extension rings, fixture studs, cable clamps, and metal straps for supporting outlet boxes which are compatible with outlet boxes being used and fulfilling requirements of individual wiring situations.
- D. Nonmetallic: NEMA OS2.

2.6 PULL AND JUNCTION BOXES

- A. Small Sheet Metal Boxes: NEMA OS 1.
- B. Sheet metal boxes over 12" in any dimension shall comply with the requirements of Article "Enclosures and Cabinets" of this Section.
- C. Boxes for Outdoor and Wet Locations: Flat flanged, surface-mounted, UL listed as rain tight, galvanized cast iron box and cover with neoprene gasket and stainless steel cover screws.
- D. Boxes for Buried Flush Grade Locations: NEMA 250, Type 6, flat flanged, UL listed as watertight, galvanized cast iron, aluminum or PVC box.
 - 1. Cover: Nonskid cover with neoprene gasket and stainless steel cover screws.
 - 2. Cover Legend: "Electric" or "Communications" as appropriate.

2.7 BOX EXTENSIONS

- A. Prohibited on new construction.

2.8 ENCLOSURES AND CABINETS

- A. Hinged-Cover Enclosures: NEMA 250, Type 1 in dry locations, and Type 4 in wet or damp locations, with continuous hinge cover and flush latch.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
- B. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage, and include accessory feet where required for freestanding equipment.

2.9 EXPANSION / DEFLECTION FITTINGS

- A. Provide an expansion/deflection fitting in each concealed or exposed electrical run crossing a building expansion joint. Fittings shall be complete with bronze end couplings, neoprene sleeves, tinned copper braid integral bonding jumper and stainless steel bands. Expansion/deflection fittings shall be suitable for the size and type of conduit run they connect. Bonding jumper shall comply with NEC and UL requirements.

- B. Expansion/deflection fitting shall accommodate the following movements without collapsing or fracturing the conduit and damaging the wires it contains:
 1. Axial expansion or contraction up to 3/4-inch.
 2. Angular misalignment of the axes of the conduits up to 30 degrees in all directions.
 3. Parallel misalignment of the axes of the conduits up to 3/4-inch in all directions.
- C. Expansion/Deflection fitting shall be OZ/Gedney Type "DX" or approved equal by Crouse Hinds (Type XD).

2.10 BUSHINGS

- A. Bushings for 1-inch conduit and smaller shall be self-extinguishing thermoplastic type - 100°C temperature rating.
- B. Bushings for 1-1/4" conduit and larger shall be malleable iron body with 150 degrees Celsius insulating ring. Insulating material shall be locked in place and non-removable.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine surfaces to receive raceways, boxes, enclosures and cabinets for compliance with installation tolerances and other conditions affecting performance of raceway installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 RACEWAY REQUIREMENTS

- A. Conduit Application Schedule:

Application	Conduit Type	Remarks
In or under concrete slab	RGS	
Exposed exterior locations.	RGS	Use threaded or rain-tight fittings.
Wet interior locations.	RGS	Use threaded or rain-tight fittings.
Exposed dry interior locations up to 7'-0" AFF where subject to physical damage.	RGS	
Exposed dry interior locations above 7'-0" AFF and up to 7'-0" where not subject to physical damage.	EMT	
Exterior Underground	RNC (Sched. 40 PVC)	RGS Elbows/Sweeps
Equipment connections in dry interior locations.	FMC (e.g. Greenfield)	Short lengths only (maximum 6 feet).
Equipment connections in wet interior locations.	LFMC (e.g. Sealtite)	Short lengths only (maximum 6 feet). Use threaded or rain-tight

		fittings.
Equipment connections in exterior locations.	LFMC (e.g Sealtite)	Short lengths only (maximum 6 feet). Use threaded or rain-tight fittings.
Concealed in dry wall construction.	EMT	
Concealed above suspended ceilings.	EMT	
Concealed in masonry walls.	EMT	

1. Provide Flexible Metal Conduit (FMC), e.g. Greenfield, in short lengths (maximum 6 feet) for the connection of lighting fixtures, dry type transformers and any vibrating equipment. The flexible connections to recessed fixtures and equipment shall be sufficient slack to permit removal of fixture.
2. Provide Liquidtight Flexible Metal Conduit (LFMC), e.g. Sealtite, in short lengths (maximum 6 feet) for the connection of exterior equipment, motors and equipment in damp or wet locations as defined in Division 26 Section 260500, *Common Work Results for Electrical*.
3. Aluminum conduit is prohibited.
4. For exposed rooftop applications and where indicated on the drawings, Rigid Non-metallic Conduit may be used as permitted in Article 347 of the NEC, with or without concrete encasement. Where rigid non-metallic conduit is exposed, it shall be Schedule 40 PVC, with all provisions for thermal expansion/contraction as recommended by the Manufacturer.
5. PVC conduits for electric and telephone services shall be encased in 2 in. concrete envelope. Conduits shall be rigid same as above and beyond 5 feet of the building shall be non-metallic PVC equal to Carlon Type EB encased in concrete.
6. Rigid Polyvinyl Chloride (PVC) Conduit may be used underground and under slabs except where rigid metal conduit is required.

B. Fittings:

1. All fittings to match conduit material and to be suitable for the purpose intended. Join conduit with fittings designed and approved for the purpose and make joints tight.
2. Provide UL listed compound fitted sealing fittings for NEC-required locations, for conduits passing from interior to exterior, and at the interface of widely different space temperatures such as refrigeration or cold storage rooms where conduits pass from warm locations to cool locations, such as the boundaries of air conditioned spaces and non-conditioned air spaces. For concealed conduits install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces.
3. Provide expansion fittings with bonding jumpers where conduits cross expansion joints or where otherwise required to compensate for thermal expansion and contraction. Provide expansion fittings in each straight uninterrupted run of surface-mounted conduit, both horizontal and vertical, in excess of 200 feet. Distance between fittings shall not exceed 200 feet. The Contractor shall refer to the Architectural Drawings for expansion joint locations.
4. Fasten rigid steel conduit with threaded galvanized steel fittings, double locknuts, and insulated bushings. Insulated bushings shall be OZ/Gedney type "B", or equal.
5. Fasten EMT conduit with "Concretight" or "Raintight" compression fittings made from galvanized steel or malleable iron. Fittings using set screw or indentations as a means of attachment or made from cast "white metal" are prohibited. All connectors shall have insulated throats.

6. Fasten liquid-tight conduit with fittings incorporating a threaded ferrule, nylon sealing ring, and steel or malleable iron compression nut and body. Furnish Crouse Hinds metallic liquid-tight fittings, or equal.
7. Fasten Flexible Metallic Conduit (FMC) with Thomas & Betts (T&B) "Tite-Bite" insulated connectors, or equal.
8. Watertight fittings shall use a copper base anti-corrosive conductive compound. Provide watertight fittings in conduits exposed to weather, in wet locations, in underground locations, and in slabs.

C. Box Locations:

1. Electrical boxes shall accommodate wire pulling, splices, taps, equipment connections and Code compliance.
2. Coordinate access doors as required to provide access to boxes in hard ceilings and similar inaccessible areas.
3. Provide cast box (with threaded hubs) in exterior enclosures, high traffic areas (surface installations), and as specified by Owner.

D. Outlet Boxes:

1. Outlet boxes for concealed work shall be zinc-coated or cadmium-plated sheet steel boxes suitable for the service and type outlet.
2. Boxes and conduit fittings for exterior locations, all damp or wet locations, and exposed locations subject to damage shall be NEMA 4 cast aluminum, cast steel or cast iron type with threaded hubs for conduit entrance and gasketed cover plates.
3. Extra large boxes shall be provided in accordance with the National Electrical Code where necessary to prevent crowding of wires in the box.
4. Plastic boxes and cast "white metal" boxes classified as NEMA 4 will not be acceptable.
5. Outlet boxes in unplastered brick or block walls shall be provided with deep square-cut device covers. They shall be set so that the brick or block can be cut and fitted closely to the cover opening and so that the standard wall plate will cover the joint between the brick or block and the box.
6. All outlet boxes used for supporting fixtures shall be furnished with malleable iron fixture studs of "no-bolt" type secured by locknut.
7. Provide support for boxes occurring in suspended ceilings. Outlets in ceilings directly on bottom of joists shall be supported independent of ceiling construction. Outlets in suspended ceilings shall not be supported from ceiling construction.
8. All boxes, whether outlet, junction, pull, or equipment, shall be furnished with appropriate covers.
9. No sectionalized boxes shall be used.
10. Pack-in-back outlet boxes are not permitted. Separate boxes a minimum of 6" in standard walls and a minimum of 2 feet in acoustical walls.
11. Provide knockout closures for unused openings.
12. Provide blank coverplates for all unused boxes.
13. For multiple device installations, provide multi-gang boxes. Sectional boxes are not permitted. Provide barrier separation of different voltage conductors in the same box.
14. Thoroughly coordinate mounting heights of boxes with casework and backsplash heights.
15. Provide recessed outlet boxes in finished areas, supported from interior partition studs. Supports are to be stamped steel stud bridges for hollow stud walls and adjustable steel channel fasteners for flush ceiling outlet boxes.

16. Provide back supports for boxes in metal stud walls.

E. Junction and Pull Boxes:

1. Junction and pull boxes shall be furnished and installed as shown or where required to facilitate pulling of wires or cables. Such boxes shall be installed in accessible locations. All boxes for concealed work shall be constructed of 12 gauge USS galvanized sheet steel minimum, unless otherwise specified or indicated and provided with mounting brackets and flat screw covers secured in position by round head brass or stainless steel 300 grade machine screws. Boxes for exterior work shall be cast aluminum or galvanized cast iron type with threaded hubs unless otherwise directed. Gasketed cover plates shall be furnished for outdoor installation.
2. Provide barrier (separators) where different system voltage share the same box.
3. Wherever possible, locate pull and junction boxes above accessible ceilings in finished areas.
4. Pull or junction boxes shall be supported independently of conduit.
5. In flush grade outdoor applications, unit shall be adequately supported against settling or tipping. Where heavy traffic or poor soil compaction exists, cast box in a concrete base which provides 6" of cover around and under the box.

3.3 INSTALLATION

- A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.
- B. Furnish and install a separate and independent raceway system as shown on the Drawings for each of the various wiring systems including, but not limited to the following:

Control Wiring
Emergency
Fire Alarm System
Lighting
Optional Standby
Power

1. All raceway systems shall be completely wired as specified herein, shown on drawings and/or required for satisfactory operation of the various systems.
2. Raceways, generally, shall be concealed conduit as specified herein. Where wiring troughs are required or used to facilitate the wiring installation, they shall be equal to Square D Company's Square-Duct and fittings, with hinged cover arranged for total removal, all finished baked enamel and all components U/L listed. The gutters shall be of ample size to accommodate conductors therein and as required by the NEC.
Support all conduit not embedded in concrete or masonry such that strain is not transmitted to outlet boxes and pull/junction boxes, etc. Supports to be sufficiently rigid to prevent distortion of conduits during wire pulling.

- C. Minimum Raceway Size: 3/4-inch trade size (DN21), 1-inch trade size for exterior underground work.
- D. Conceal conduit and EMT, unless otherwise indicated, within finished walls, ceilings, and floors.

- E. Electrical Metallic Tubing (EMT) shall be used for the following unless otherwise indicated:
 - 1. Branch circuits for lighting, receptacles, and power concealed in:
 - a. Dry wall construction.
 - b. Suspended ceilings.
 - c. Masonry walls.
 - 2. Exposed in equipment room areas as needed to serve fixed equipment.
- F. Rigid Galvanized Steel Conduit (RGS) shall be used for the following, unless otherwise indicated:
 - 1. Branch circuits and feeders for lighting, receptacle and power, installed exposed in areas subject to physical damage.
- G. ATC (Automatic Temperature Control) and Fire Alarm system wiring shall be installed in raceways within partitions, terminated 8" above ceiling.
- H. Wiring above ceiling shall be plenum rated cable, where required by Code.
- I. Wiring installed concealed above hard ceilings and exposed in areas with no ceilings shall be installed in conduit.
- J. Conduit shall be run concealed wherever possible within walls, ceilings, or floors, unless otherwise indicated or specified. Where exposed conduit runs are shown or required, they shall be run parallel to building construction and shall be suitably supported at required intervals.
- K. Conduit may be run exposed in Mechanical Equipment rooms, Electrical rooms, and where necessary in Storage rooms and unfinished areas. Where conduit is run exposed, it shall be run as close as possible to walls and ceilings and shall not interfere with equipment, ductwork and piping.
- L. Keep raceways at least 12 inches (300 mm) away from parallel runs of flues, steam or hot-water pipes and other hot surfaces above 77 degrees F. Install horizontal raceway runs above water and steam piping.
- M. Install raceways level and square and at proper elevations. Provide adequate headroom.
- N. Complete raceway installation before starting conductor installation.
- O. Support raceways as specified in Division 26 Section "Hangers and Supports". Arrange supports to prevent misalignment during wiring installation.
- P. Use capped bushings or "push-penny" plugs to prevent foreign matter from entering the conduit system during construction. Clean and plug or cap all conduits left empty for future use.
- Q. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above the finished slab. Conduit stub-ups and stub-downs shall be arranged in a neat and orderly manner and shall emerge at right angles to floors or ceilings.

- R. Make bends and offsets so the inside diameter is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.
- S. Use raceway fittings compatible with raceways and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, unless otherwise indicated.
- T. Run concealed raceways, with a minimum of bends, in the shortest practical distance considering the type of building construction and obstructions, unless otherwise indicated.
- U. Conduits shall not be installed in elevated concrete floor slabs so that composite action between the slab and beams is not affected.
- V. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
- W. Run parallel or banked raceways together, on common supports where practical.
- X. Make bends in parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- Y. Join raceways with fittings designed and approved for the purpose and make joints tight.
 - 1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
 - 2. Use insulating bushings to protect conductors.
- Z. Tighten set screws of threadless fittings with suitable tools.
- AA. Install pull wires in empty raceways. Use 1/8" 14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb (90 kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of the pull wire.
- BB. Lubricants for pulling wires shall be approved for use with the types of wire and conduit installed.
- CC. Install hinged-cover enclosures and cabinets plumb. Support at each corner.
- DD. Use conduit hubs or sealing lock nuts to fasten conduit to sheet metal boxes in damp and wet locations and to cast boxes.
- EE. Install no more than equivalent of three 90° bends between boxes. Use conduit bodies to make sharp changes in direction, as around beams. Use factory elbows for bends in metal conduit larger than 1 1/2" (50 mm) in size.
- FF. Avoid moisture traps; provide junction box with drain fittings at low points in conduit system.
- GG. Die-cast fittings of pot metal will not be accepted.
- HH. Conduits shall be free of any burrs, foreign objects, and water prior to conduit installation.

- II. Conduit placed against concrete or masonry above ground shall be fastened to the concrete or masonry with pipe straps or one screw clamp attached to the concrete by means of expansion screw anchors and screws. "Caddy Clip" type hangers or straps will be permitted only in non-exposed areas and restricted to 1/2" to 3/4" conduit.
 - JJ. Where conduits turn up out of concrete slabs and are not concealed by wall construction, bends shall be carefully made so that no portion of the radius is above the floor.
 - KK. Rigid conduit or Electrical Metallic Tubing (EMT) shall not be strapped or fastened to equipment subject to vibration or mounted on shock-absorbing bases.
 - LL. Conduit shall be installed in such manner as to insure against the collection of trapped condensation, and runs of conduit shall be without traps wherever possible. Drill 1/8" diameter weep holes where necessary.
 - MM. Conduits run to and from cabinets shall be run neatly, in accurate manner and shall emerge from the floors and ceilings at right angles thereto.
 - NN. Provide wall flanges and gasketing on conduits entering fan housings to minimize air leakage at points of penetration of housing.
 - OO. Conduit risers shall be rigidly supported on the building structure, using appropriate supports only.
 - PP. In equipment spaces, such as fan rooms, plenums, etc., conduits and outlets may be exposed, but shall avoid interference with ventilating ducts, pipes, etc.
 - QQ. Exposed conduit installed on or adjacent to ventilating ducts shall be installed after the ducts are in place, and shall be run from ceiling or wall junction boxes in such manner as to retain accessibility to junction box covers and to permit future removal or replacement of ducts.
 - RR. Conduits and other electrical items shall not be fastened to, or supported from ventilating ducts but shall be separately supported. The method of supporting and details of the supporting members shall be reviewed by the Owner's Representative. In no case shall screws penetrate the sheet metal of the ducts.
 - SS. Exposed conduit run on surface shall be supported according to Code and within three feet of each outlet, junction box, or cabinet, by galvanized malleable conduit clamps and clamp backs. Suspended conduit shall be supported every five feet by conduit hangers and round rods, or where two or more conduits are run parallel, by trapeze hangers suitably braced to prevent swaying.
 - TT. Screws for all exposed work shall be stainless steel, unless otherwise noted.
 - UU. Galvanized steel screws may be used for interior dry locations only.
 - VV. No running threads shall be cut or used.
- 3.4 FLEXIBLE CONNECTIONS
- A. Provide Flexible Metal Conduit (FMC), e.g. Greenfield, in short lengths (maximum 6 feet) for the final connection of lighting fixtures, dry type transformers and vibrating equipment in dry interior locations. The flexible connections to recessed fixtures and equipment shall be sufficient slack to permit removal of the same.

- B. Provide Liquidtight Flexible Metal Conduit (LFMC), e.g. Sealtite, in short lengths (maximum 6 feet) for the final connection of exterior equipment, motors and equipment in damp or wet locations as defined in Division 26 Section 260500, *Common Work Results for Electrical*.
- C. Grounding conductors with green colored insulation shall be extended through all flexible connections including fixture "whips", and fastened to terminals within the first junction boxes on either side of the flexible length.
- D. Flexible connections shall be sized per the Contract Drawings, or as required in accordance with Code; the more stringent requirement shall apply.

3.5 INSTALLATION OF TERMINATIONS

- A. Where raceways are terminated with lock nuts and bushings, align the raceway to enter squarely, and install the lock nuts with dished part against the box. Where terminations cannot be made secure with one lock nut, use two lock nuts, one inside and one outside of the box.
- B. Where terminating in threaded hubs, screw the raceway or fitting tight into the hubs so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.
- C. Open ends shall be capped with approved manufactured conduit seals as soon as installed and kept capped until ready to pull in conductors.
- D. Where conductors No. 10 AWG or larger enter a raceway, cabinet, pull box, and junction box, the conductors shall be protected by an insulated bushing providing a smoothly rounded surface.
- E. Double lock nuts shall be used at termination of rigid conduit in knock-out openings.
- F. Ends of conduits shall be equipped with insulating bushings for 1" and smaller, and insulated metallic bushings for 1-1/4" and larger. Ends of conduit shall be temporarily capped prior to installation and during construction to exclude foreign material.

3.6 INSTALLATION OF BOXES

- A. Provide grounding connections for raceway, boxes, and components as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors.
- B. Provide junction boxes, pull boxes, cable support boxes, and wireways as required for proper installation of the electrical work. Covers shall be accessible. Small junction boxes shall be similar to outlet boxes. Provide barriers (separators) where different system voltage wires share the same box.
- C. Pull boxes, cable support boxes, and large junction boxes for indoor use shall be made of Code gauge steel or no less than 12 gauge. Covers shall be held in place with stainless steel screws. Paint interior and exterior surfaces with rust-inhibitive paint. (Pull boxes and covers shall be hot-dipped galvanized.)

- D. Boxes located outdoors and in damp or wet locations shall be cast metal or alloy, fitted with screw-fastened covers and gaskets, and with threaded conduit connections. Fasteners shall be stainless steel or brass.
- E. Pull boxes shall be installed at all necessary points to prevent injury to the insulation or other damage that might result from pulling resistance or for other reasons necessary for proper installation. Pull box locations shall be approved by the Owner's representative prior to installation.
- F. Where boxes are used in connection with exposed conduit, plain covers attached to the box with a suitable number of countersunk flat head machine screws shall be used.
- G. Pull boxes with barriers shall have a single cover plate and the barriers shall be of the same gauge as the pull box.
- H. Exposed pull boxes will not be permitted in finished spaces.
- I. Location of pull boxes shall be coordinated with piping, ductwork and other equipment so as to permit sufficient clearance for maintenance and access.
- J. Pull boxes recessed in walls or partitions shall be provided with flanged type covers.
- K. Outlet boxes and covers shall be sheet steel knockout type, zinc-coated, or cadmium-plated and shall be of proper Code size for the number of wires of conduits passing through or terminating therein, but in no case shall any box be less than 4" square, or boxes at end of a run and containing a single device may be of the "handy box" type. Covers for flush outlets shall finish flush with plaster or other finished surface. Approved factory-made knockout seals shall be used in all boxes where knockouts are not intact. Boxes in concrete shall be a type which will allow the placing of conduit without displacing the reinforcing bars. Additional pull boxes shall be installed as required to facilitate pulling of wires.
- L. Outlet boxes for lighting fixtures shall be equipped with fixture supporting devices.
- M. Outlet boxes for switches shall be of the gang type.
- N. Each circuit in each pullbox shall be marked with a tag guide denoting panels to which they connect.
- O. Boxes shall be separated to prevent sound transmission. Back-to-back boxes shall not be used.
- P. Outlet boxes shall be provided with suitable plaster rings and covers or plates.
- Q. Unused knockout holes shall remain closed and those opened by error shall be closed with snap-in blanks.
- R. Outlet boxes shall not be smaller than required by Code for the number and size of wires to be installed.
- S. Outlet boxes installed in plenum ceilings shall be in accordance with applicable codes.

- T. Outlet boxes shall be installed true and plumb so that the covers or plates will be level and at uniform elevations for the types of outlets contained.
- U. Outlet boxes for switches at doorways shall be located at the strike side of the door as finally hung.
- V. Outlet box locations as indicated shall be considered to be approximate only. Determine exact locations from architectural details or from field instructions and coordinate outlet box locations with the work of other trades.
- W. Install junction and pull boxes to be accessible.
- X. Locations of junction and pull boxes requiring access panels shall be reviewed by the Owner's Representative.

3.7 PROTECTION

- A. Provide final protection and maintain conditions, in a manner acceptable to Manufacturer and Installer that ensure coatings, finishes, and cabinets are without damage or deterioration at the time of Substantial Completion.
- B. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
- C. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.
- D. Steel conduit: Conduit that shows corrosion within the guarantee period shall be replaced.

3.8 CLEANING

- A. On completion of installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.
- B. After conduits and accessories have been installed, and concreting operations completed, conduit runs shall be satisfactorily cleared of obstructions and foreign matter. Defects which might damage cable upon installation shall be corrected. Where new conduits installed are connected to new conduits installed by others and where new conduits installed are connected to existing conduits, the entire run to the nearest box or other termination point shall be cleaned.

3.9 PAINTING AND FINISHES

- A. All exterior equipment and conduits shall be painted to match adjacent surface in color as selected by Architect.
- B. All exposed conduit, boxes, equipment, etc. in finished spaces shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.

- C. Boxes for fire alarm cabling and devices shall be red, except for finished locations, where they shall be painted to match adjacent surfaces.

END OF SECTION

NOT FOR BID

DIVISION 26 SECTION 26 05 43
UNDERGROUND DUCTBANKS
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SECTION 26 05 43 - UNDERGROUND DUCTBANKS

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.
- B. Sections of other Divisions in this Specification which relate to excavation and concrete construction.

1.2 SUMMARY

- A. This Section includes complete concrete ductbank construction and direct buried materials and methods for outside power systems transmission and distribution.
- B. This Section specifies underground duct placement, materials, and installation procedures.

1.3 CONTRACTOR RESPONSIBILITIES

- A. All work described in this Section shall be performed and paid for under Division 26.
- B. Existing Subsurface Utilities: Existing subsurface utilities are shown on the plans to help the Contractor avoid damage to essential utilities which must remain in service. Take reasonable steps to ascertain the exact location of all underground facilities prior to doing work that may damage such facilities. If the discovery of underground facilities not indicated on the plans or in a location different from what is indicated on the plans, protect such facilities, notify the Owner's representative immediately, and record actual conditions found onto the record drawings.
- C. Construction Staking:
 - 1. Provide the stakes and reference marks necessary for the construction of the improvements covered by this Contract.
 - 2. Control stakes which constitute reference points for all Construction work shall be conspicuously marked with red flagging tape. Provide responsibility to inform employees and Subcontractors of the stakes' importance, and the necessity for their preservation. The cost of replacing such controls, should it become necessary for any reason whatsoever, shall be furnished at no additional cost to the Owner.

1.4 QUALITY ASSURANCE

- A. Installer: Company specializing in cast-in-place concrete structures with a minimum of three years documented experience.

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.
- B. Materials: All materials shall be new and the best of their respective kinds, free from all defects and as specified on the plans and the specifications or as accepted by the Project Engineer. Furnish materials or manufactured articles or shall do work for which no detailed Specifications are set forth, the materials or manufactured articles shall be of the best grade in quality and workmanship obtainable on the market from firms of established good reputation, or if not ordinarily carried in stock, shall conform to the usual standards of first-class materials or articles of the kind required, with due consideration of the use to which they are to be put. In general, the work performed shall be in conformity and harmony with the intent to secure the best standard of Construction and equipment of the work as a whole or in part.
- C. Manufacturer's Recommendations: Whether specifically mentioned or not in these Specifications, all materials, equipment, devices, etc., shall be installed in a manner meeting the approval of the manufacturer of the particular item.
- D. Codes and Standards: Provide underground ducts and manholes conforming to the following:
 1. National Electrical Manufacturers Association (NEMA) - conform to the manufacturing standards of the following:
 - a. RNI: PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 - b. TC 2: Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).
 - c. TC 3: PVC Fittings for Use with Rigid PVC Conduit and Tubing.
 - d. TC 6: PVC and BAS Plastic Utilities Duct for Underground Installation.
 - e. TC 7: Smooth-Wall Coilable Polyethylene Electrical Plastic Duct.
 - f. TC 8: Extra-Strength PVC Plastic Utilities duct for Underground Installation.
 - g. TC 9: Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation.
 2. Underwriters Laboratories, Inc. (UL): Conform to the following:
 - a. 6: Rigid Metal Conduit.
 - b. 651: Schedule 40 and 80 Rigid PVC Conduit.
 - c. 651A: Type EB and A Rigid PVC Conduit and HDPE Conduit.
 3. American Concrete Institute (ACI):
 - a. 318: Building Code Requirements for Reinforced Concrete.
 4. American Society for Testing & Materials (ASTM):
 - a. F512: Smooth-Wall PVC Conduit & Fittings for Underground Installation.
- E. Certification: Manufacturer shall be a company specializing in ductbank structures with a minimum five years documented experience.

1.5 SUBMITTALS

- A. Submit shop drawings and product data for all conduit, duct, ductbank materials, accessories, and miscellaneous components. Submit product data for each type of manufactured material and product indicated.
- B. Indicate material specifications, dimensions, capacities, and reinforcing details. Submit concrete product data, concrete mix design, and certified mill test reports for steel bars.
- C. Submit coordination shop drawings of ductbank and underground cable installations including profiles and elevations of all utility crossings. Proposed deviations from details on the Drawings shall be clearly marked on all Submittals.
- D. Record Documents: Show dimensional locations of underground ducts, handholes, and manholes.

1.6 SITE CONDITIONS

- A. General: Clearing work shall not begin until temporary fences, barricades, warning signs and other pedestrian control devices are installed.
- B. Traffic Access:
 - 1. Conduct operations and schedule cleanup in a manner which causes the least possible obstruction and inconvenience to adjacent property owners, pedestrians and vehicular traffic. Furnish, erect, construct and maintain such temporary fences, barriers, lights, reflectors, cones, signs, ramps, etc., that may be necessary to adequately provide separation and warn the public of work in progress and of any existing dangerous conditions. This requirement shall apply continuously and shall not be limited to normal working hours.
 - 2. Maintain continued access to parking areas, roads, abutting properties, and other facilities which the construction will cross.

PART 2. PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering the specified products that may be incorporated in the work, include, but are not limited to, the following:
 - 1. Conduit and Fittings:
 - a. Carlon Electrical Products.
 - b. George-Ingraham Corporation.
 - c. Condux International.

2. Ductbank Accessories:
 - a. Carlon.
 - b. Osburn Associates.
 - c. Underground Devices, Inc.
 - d. OZ/Gedney.

2.2 UNDERGROUND DUCTBANKS

- A. General Underground ductbanks to be arrangements of single bore, PVC plastic conduits concrete encased. The number and size of conduits to be as indicated. Turn up connections through slabs or floors shall be rigid metal.
- B. Material:
 1. Conduit and Fittings:
 - a. Type II, heavy wall Schedule 40 PVC plastic, sunlight UV resistant, in accordance with the requirements of NEMA publications TC-2 and TC-3 (fittings).
 - b. Rigid galvanized heavy wall steel conduit (UL 6) with threaded couplings.
 - c. Rigid Metal Conduit, PVC Coated, UL 6, galvanized steel unthreaded type, coated with a polyvinyl chloride (PVC) sheath bonded to the galvanized exterior surface, nominal 40 mils thick, conforming to NEMA AN 1, Type A40.
 - d. Conduit and fittings shall have a temperature rating at least equal to the operating temperature of the cable which it contains, minimum 90 degrees C. Conduit and fittings shall be free from all substances that injuriously affect any wire or cable insulation.
 - e. The Manufacturer shall certify that the plastic is 100 percent virgin material and the finished product meets the specifications. All PVC conduit and fittings shall have solvent-weld connections and shall provide a water-tight joint.
 2. Concrete Comply with ACI 318 - 3,000 psi test in 28 days - See Division 03, Section *Cast-in-Place Concrete*.
 - a. Cement: Portland Blast-Furnace Slag Cement, Type IS or equal meeting ASTM C595 Specifications and the requirements of ACI 318 and 301.
 - b. Fine Aggregate: Concrete sand meeting requirements of ASTM C33.
 - c. Course Aggregate: ASTM #57 crushed limestone, meeting requirements of ASTM C33.
 - d. Air-Entraining Admix: Complies with ASTM C260 Standard Specifications for Air Entraining Admixtures for Concrete.
 - e. Water Complies with ASTM C94 Standard Specifications for Ready-mixed Concrete.
 3. Use pea gravel aggregate for void-free duct penetration.
 4. Reinforcing: Deformed conforming to ASTM A615 - Grade 40, minimum 3/4". Provide coated rebar where exposed to earth, such as on ductbank stubouts. Bars shall be free of loose scale, rust, or other coatings that will reduce bond. per Division 03, Section 033000, *Cast-in-Place Concrete*.

5. Spacers: Manufactured precast plastic assembly, base spacer, top spacers and intermediate spacers, to maintain 4-inches between conduits and completely enclosed and locked conduit assembly. Set on masonry leveling blocks prior to pour.
 6. Joint Sealant: Watertight as recommended by conduit manufacturer.
 7. Cable Sealing Bushings: OZ type CSB, with PVC coated discs, or equal.
 8. Thruwall and Floor Seals: OZ type *FSK* or *WSK*, or equal.
 9. Expansion Joints: Expansion joints shall be *Dylite*, as manufactured by Copper, Scorogord, or Dow Chemical and shall conform to ASTM D-1752, Type II.
 10. Construction Joints: Construction joints shall be formed using *Jahn* Screed Joint materials as manufactured by Superior Concrete Accessories, Inc.
- C. Conduit:
1. Size as indicated on the Drawings. If conduit sizes are not indicated on the Drawings, then the conduits shall be sized as follows:
 - a. Four inches nominal for 600 volts or lower and for Communication.
 - b. Five inches nominal for voltages above 600 volts.
- D. Elbows rigid heavy wall galvanized steel with a minimum bend radius of 26 inches (915-mm).
- E. Conduit Termination in Utility Holes and Buildings.
1. End Bells: Manufactured end bells of appropriate sizes at each end of conduit. When entering a new building or a new manhole, the end bells for PVC shall be a pre-manufactured system (as manufactured by *Formex*, or equal) with conduit seals, provision for roughing into the concrete, and water stops.
 2. Bushings: Pre-manufactured groundable steel bushings of appropriate sizes where bell ends are not used. Steel bushings shall be used on all metal conduit. When entering a new building, or a new manhole, the bell ends for PVC shall be a pre-manufactured system (System as manufactured by *Formex* or equal) with conduit seals, provisions for roughing into the concrete pour and water stops.
 3. Seals: When entering, below grade, an existing building or manhole, the concrete shall be core-drilled for the appropriate size conduit and seal. The seal shall be a mechanical interlocking assembly seal of modular synthetic rubber links properly sized to fit the pipe and tightened in place, in accordance with the manufacturer's instruction.
 4. Fire Stopping/Sealant: All cable filled conduits shall be sealed with 3M Fire Barrier 2001 Silicone RTV Foam Conduit Sealant manufactured by 3M Fire Protection Products, or approved equal.
- F. Plugs. Closure plugs or caps of the same material as the conduit at the ends of the unused sections of manholes, and at building entrance openings.
- G. Pull wire: Provide a polypropylene, twisted yellow, rot and mildew-resistant 3/8" minimum pull rope (2400 lbs. tensile strength) in each empty duct.
- H. Grounding: Steel grounding bushings shall be grounded to the manhole or junction box ground. On steel conduit with end bells, provide an Appleton Catalog No. XJB Series or equal bonding fitting with bonding strap. Connect bonding strap to ground wire in manhole or junction box.

- I. Drainage Assembly: All ducts shall drain to an open end - preferably to a manhole. Or away from the building.

2.3 ACCESSORIES

- A. Duct Supports: Rigid PVC spacers selected to provide minimum duct spacings and concrete cover depths indicated, while supporting ducts during concreting. Spacers shall be interlocked horizontally only. Provide nylon tie-downs to hold ducts to spacers. Concrete blocks are prohibited for duct spacers.
- B. End Bells: Flared, smooth-surfaced fittings of same material as conduit; if of different material, including adapter for connection to conduit.
- C. Warning Tapes:
 - 1. Refer to Division 26 Section, "Electrical Identification" for product requirements.
 - 2. Bury marker tape 12-inches below grade above every ductbank and buried conduit.

2.4 TEST PITS

- A. Provide test pits to locate all utilities and structures. Provide test pits as necessary to determine actual locations and profiles of obstructions to proposed work.
- B. Verify existing utilities, locations, and inverts and points of connection.

2.5 PAINTING

- A. General: All exposed conduit shall be primed and painted to match existing building exteriors.
 - 1. First coat: Zinc Duct - Zinc oxide primer house and trim paint.
 - 2. Second Coat: Type and color to match existing building walls and/or trim where applicable.

PART 3. EXECUTION

3.1 LOCATION AND LAYOUT

- A. Indicated plans and profiles - approximate, based on field information and available as-built plans.
- B. Actual locations and profiles - based on test pits to locate all shown utilities and structures. Test pits at beginning, center, end, and at all ductbank bends and utility crossings.
- C. Plan and profile adjustments - All provided at no additional cost to Owner, subject to approval.

- D. Examine site to receive ducts and handholes for compliance with installation tolerances and other conditions affecting performance of the underground ducts and manholes. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. In accordance with NEMA publication TC-2 and manufacturer's recommendations.
- B. Top of envelope below grade - Minimum as follows: as indicated on the Drawings.
- C. Concrete envelope - 3 inches minimum beyond surface of any conduit, minimum 2 inches between conduits. Top of ductbank shall be crowned to prevent puddling of water.
- D. Seal and Thru Wall Fittings - At entrances to buildings for watertight construction.
- E. Sweeps and bends - Minimum 25 foot radius (except at conduit joints) unless otherwise approved to accomplish changes in direction of runs either horizontally or vertically. Double offsets: Minimum 100 foot radius. Sweep bends may be made up of one or more curved or straight sections or combinations thereof. Manufactured bends shall have a minimum radius of 36 inches.
- F. Mandrel conduits - Mandrel 12 inch long, 1/4 inch less than conduit I.D. Draw a testing mandrel through each duct.
- G. Clean conduits - After mandrel, with stiff brush, remove particles or debris. Immediately install end plugs after cleaning.
- H. Pull Line - Provide 100-pound-tested nylon pull line in all conduits, including spares. Provide 3 feet of slack at each end of conduit and spares.
- I. Stagger vertical conduit joints - Minimum 6 inches. All joints shall have couplings installed.
- J. Reinforcing steel - Provide reinforcing steel the entire length of the duct system. Provide four #4 bars, one in each corner minimum, overlap the joints 12-inches, and tie them into the respective utility, vault, and buildings, etc. Rebar shall not be installed less than 2-inches from sides of any duct.

3.3 EXCAVATION, BACKFILLING, COMPACTING AND SITE PREPARATION

- A. Provide all excavating and backfilling and site preparation necessary to install underground ductbanks, cables, etc., included in this section of the work. Excavation and backfill shall be performed in accordance with the requirements of Division 26 Section, "Common Work Results for Electrical".
- B. Install forms on sides of the ductbank if the trench is not of the proper firmness to prevent cave-in. Provide all required excavating, shoring, sheeting, bracing, and backfilling.

- C. The bottom of the trench shall be undisturbed earth. If the trench bottom is too low for proper grade, fill to the proper level with sand and mechanically compact it. Cut trenches neatly and uniformly.
- D. Each excavated section from manhole to manhole and from manhole to building shall be completely excavated and graded before any duct is laid in that section.
- E. Provide underground detectable warning tape 12-inches below finish grade over all ductbanks.
- F. Excavation and Backfill: Do not use heavy-duty, hydraulic-operated compaction equipment.
- G. After excavation of the trench, stakes shall be driven in the bottom of the trench at four-foot intervals to establish the grade and route of the duct bank.
- H. Pitch the trenches uniformly towards manholes or both ways from high points between manholes for the required duct line drainage. Avoid pitching ducts towards buildings whenever possible.
- I. The walls of the trench may be used to form the side walls of the duct bank provided that the soil is self-supporting and that concrete envelope can be poured without soil inclusions. Forms are required where the soil is not self-supporting.
- J. After the concrete-encased duct has sufficiently cured, the trench shall be backfilled to grade with earth.
- K. Restore surface features at areas disturbed by excavation, and establish original grades except as otherwise indicated. Replace removed sod as soon as possible after backfilling is completed. Restore all areas disturbed by trenching, storing of dirt, pipe laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.
- L. Restore disturbed paving.
- M. Remove pavements, sidewalks, curbs, and gutters where necessitated by construction of ducts.
- N. Place temporary bituminous pavement when required by the sequence of operations.
- O. On completion of distribution systems construction, replace pavements, sidewalks, curbs and gutters.
- P. Surplus earth from the trenches, after compacting, shall be removed and disposed of.

3.4 CUTTING AND PATCHING

- A. Provide all cutting and patching necessary for the installation of the electrical work. Any damage done to the work already in place by reason of this work shall be repaired expense by a qualified mechanic experienced in such work. Patching shall be uniform in appearance and shall match with the surrounding surface.

- B. Existing Obstructions: Where drawings indicate that underground conduits are to cross under existing roadways, walks or other similar paved areas, steel conduits will be driven under such areas in lieu of installing the conduits in trenches as specified above. After installation of conduit by either method, all existing paved or grass areas which have been disturbed in any way shall be restored to their original conditions. Where drawings indicate spare conduits under existing roadways, walks, and other similar paved areas, all ends of conduits shall be capped five feet beyond the pavement and adequately protected from mechanical damage. The ends of these conduits shall be marked by the placement of concrete monuments. Minimum size shall be 6 inches in diameter by 18 inches long set flush in ground with "S/C" indented in top to signify spare conduit.
- C. Conduit Protection at Penetrations: Galvanized conduits which penetrate concrete shall be PVC-coated and shall extend at least 2 inches within the concrete to the first coupling or fitting outside the concrete.
- D. Provide all cutting and patching necessary for the installation of the ductbank work. Any damage done to the work already in place by reason of this work shall be repaired at the Contractor's expense by a qualified mechanic experienced in such work. Patching shall be uniform in appearance and shall match with the surrounding surface.
- E. Patching shall be done in accordance with the requirements of Division 02 for the appropriate disturbed surface materials.
- F. Work with extreme care near existing ducts, conduits, cables, and other utilities to avoid damaging them.

3.5 PLACEMENT OF CONDUIT

- A. Within five (5) feet of each existing building wall or utility hole penetration, install heavy wall galvanized steel conduit within the concrete envelope to provide protection against vertical shearing.
- B. Core drill all existing walls and footings and waterproof per Division 26 using an assembly of rubber links of mechanical seal of the proper size for the pipe and tighten in place, in accordance with the manufacturer's instruction, after the new conduit is installed.
- C. Install spacers as recommended by the conduit manufacturer and requirements stated above, but not to exceed a maximum of four feet on center for PVC conduit and eight feet on center for steel conduit. Bottom spacers shall rest on 8-inch x 16-inch x 2-inch minimum concrete pads to prevent them from sinking into the ground and reducing the bottom concrete cover. Stagger conduit joints in concrete encasement 6 inches minimum horizontally.
 - 1. Spacer assembly shall consist of base spacers, intermediate spacers, and top spacers to provide a completely enclosed and locked conduit assembly.
 - 2. Before placing concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete placement. Anchoring shall be done by driving reinforcing rods adjacent to every other duct spacer assembly and attaching the rod to the spacer assembly.
 - 3. Set on masonry leveling blocks prior to pour.

- D. Pitch conduit properly for drainage to manhole or pull box and to prevent low pockets or irregular dips between conduit ends. Minimum pitch to be 4 inches per 100 feet.
- E. Depending on encasement necessary for duct formation, place conduits on spacers. The minimum encasement thickness 1-1/2-inches on all sides.
- F. Lay conduits using spacers to provide tier spacing.
- G. Make tight conduit joints by complying with recommendations of conduit manufacturer, using coupling jointing compound or PVC primer and solvent cement. All joints in conduits and fittings shall be made up tight and shall be watertight. All threaded portions of steel conduits that are not to be encased in concrete and adjoining ends of conduits, couplings and fittings, shall be heavily coated with asphaltum after installation. All connections between conduits of different types shall be made in an approved manner, using adapters of other materials and methods recommended for the purpose by the conduit manufacturers.
- H. Provide not more than one 90-degree bend or equivalent between points for primary conduit.
- I. Provide flush bell ends on duct at buildings. When entering a new building the bell ends for PVC shall be a pre-manufactured system (system as manufactured by Fortex or equal) with conduit seals and provisions for roughing into the concrete.
- J. Provide insulated, grounding bushings on duct ends in equipment enclosure.
- K. Plug or cap empty conduits. Provide standard manhole plugs.
- L. Seal all spare ducts and conduits, at all new and existing building entrances and at outdoor terminations at equipment pedestals with a suitable compound to prevent the entrance of moisture and gases.
- M. After ducts are in place and before the concrete is poured, the installation shall be inspected by the Engineer. Notify the Engineer at least two days before the time of inspection.
- N. Clear conduit by rod and pull an approved test mandrel from structure to structure or from structure to the conduit termination.
- O. Leave nylon or polyester pull line in each conduit, tagged to identify the conduit's point of origin, contents and final destination.
- P. Conduit Couplings: Conduit couplings shall be staggered so that couplings on adjacent conduits will not lie in the same transverse plane. End bells shall be spaced approximately 9 inches center to center at face of manhole wall for 4-inch conduits and proportionately spaced for other sizes. The change from regular conduit spacing to end bell spacing shall start 10 feet from the face of the manhole wall and shall be made in such a way that the slope of any conduit will not be less than that of the main bank and no trap will be formed. New conduit entrances into existing manholes and building walls shall enter at the most desirable locations consistent with grading requirements and existing entrance and shall be waterproofed in a satisfactory manner.

- Q. Bends: Conduit generally shall be straight between manholes or upturned elbows. Where bends are unavoidable in non-metallic conduits, they may be made by assembling couplings at a slight angle, provided the watertight seals are not broken and the resulting radius is not less than 100 feet. For radii less than 100 feet, 5-degree angle couplings or 5-degree factory-made bend sections shall be used.
1. Install top of duct bank minimum 30 inches below finished grade.
 2. Terminate conduit in end bell at manhole entries.
 3. Provide minimum 3-inch concrete cover at bottom, top, and sides of duct bank.
- R. Multiple conduit: Install multiple conduit as follows:
1. Multiple conduit runs, direct burial or in duct bank, shall be supported on preformed, non-metallic separators. Spacing between exterior surfaces of conduits generally shall be not less than the following:
 - a. Two (2) inches between telephone conduit.
 - b. Two (2) inches between conduits containing cables operating at not over 600 volts.
 - c. Six (6) inches between a telephone conduit and any power conduit in the same envelope.
 - d. One and a half (1-1/2) inches between conduits containing cables operating at over 600 volts.
 - e. Spacing between separators shall be close enough to prevent sagging of conduits and breaking of couplings and watertight seals. Separators shall also be spaced to keep deformation of conduit at the separators 0.10-inch or less. Separators shall be secured with cords where necessary and no tie wires, reinforcing rods or other metallic materials shall be placed around the conduits, either individually or in groups, in such a manner as to form a magnetic loop.
 2. Multiple conduit runs shall be arranged substantially as shown on the drawings, but minor changes in location or cross sectional arrangement shall be made as necessary to avoid obstructions. Where conduit runs cannot be installed substantially as shown because of conditions not discoverable prior to digging of trenches, the condition shall be referred for instructions before further work is done. All underground conduit work shall be coordinated with other outside service work. Existing outside services shall be maintained in operation unless directed otherwise.

3.6 CONCRETE WORK

- A. Unless otherwise indicated, all concrete work for electrical manholes, ductbanks, etc., shall be provided under this section of the work. All concrete work shall conform to the requirements as hereinbefore specified in Division 03 entitled Concrete. All concrete shall be minimum 3,000 psi test at 28 days. Concrete for ductwork shall be Class B, 470 lb. (5 sacks) of Portland cement per cubic yard.
- B. Supervise the placement of concrete in the ductbank.

- C. Complete entire section of conduit from utility pole to manhole to building before encasement by concrete. The entire conduit system shall be tied together with wire and anchored to the bottom of the trench to prevent any movement or floating while pouring concrete.
- D. Place concrete as specified in Section. Top of concrete envelopes shall be not less than 24 inches below grade.
- E. Provide minimum of 3-inches (76mm) of concrete cover over conduit at the top, bottom, and sides of the duct bank. Provide crowned top on the concrete to prevent water accumulation. At poured manholes, tie duct and manhole reinforcing steel together to provide a permanent connection.
- F. Place concrete continuously from utility to manhole to building without interruption.
- G. Extend concrete envelope to finish floor grade or interior wall surface in buildings at finish pad grade at equipment. Maintain moisture seal.
- H. Conduits in completed ductbanks shall be straight to within 1/4 inch per 100 feet in both vertical and horizontal directions.
- I. Pull solid mandrels and swabs (diameter 1/4 inch smaller than conduit) through each conduit in completed ductbank before installing cables.
- J. Concrete -Encased Nonmetallic Ducts: Support or plastic separators coordinated with duct size and required duct spacing, and install according to the following:
 - 1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, and secure separators to the earth and to ducts to prevent floating during concreting.
 - a. Do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups. Provide nonferrous tie wires to prevent displacement of the duct during pouring of concrete.
 - b. Provide spacers staggered at least 6 inches vertically along the length of the duct run to eliminate the potential for a weak vertical shear plane in concrete encasement.
 - c. Provide a minimum of four spacers per 20-foot interval (5 feet maximum) along the length of the duct run.
 - 2. Concreting: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not use power-driven agitating equipment unless specifically designed for duct bank application. Pour each run of envelope between manholes or other terminations in one continuous operation. When more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (18mm) reinforcing rod dowels extending 18 inches (450 mm) into the concrete on both sides of joint near the corners of the envelope.
 - 3. Reinforcing: Provide reinforcing steel bars at the top and bottom of each concrete envelope as shown on Drawings and at the present and indicated future locations, including but not limited to the following:

- a. Crossing fill or loose soil (4 feet beyond the exterior limits on each side).
 - b. Crossing other utilities (8 feet beyond the exterior limits on each side).
 - c. Entering buildings, manholes, vaults, etc. (20 feet beyond).
 - d. Crossing vehicle roadways and parking areas (underneath and 20 feet beyond the exterior limits on each side).
 - e. Rebar shall not be installed less than 2-inches from the sides of any duct.
 - f. Under all pavement (6 feet beyond edge of pavement).
 - g. Crossing soils and rock where the bottom of the trench is not undisturbed soil or the bearing is less than 3,000 psf, then the entire distance such conditions exist, plus 10 feet either side of these conditions.
4. Forms: Use the walls of the trench to form the side walls of the duct bank where the soil is self-supporting and concrete envelope can be poured without soil inclusions. Otherwise, use forms.
 5. Minimum Clearances Between Ducts: Three inches (75 mm) between ducts and exterior envelope wall, 3 inches (75 mm) between ducts for like services, and 6 inches (150 mm) between power and signal ducts. Provide plastic spacers to maintain clearance.
 6. Depth: Except as otherwise indicated, install top of duct bank at least 30 inches (750 mm) below finished grade in nontraffic areas for 600 volts and below. Install at least 36 inches (900 mm) below finished grade in vehicular traffic areas for 600 volts and above.
- K. Partial Pouring: Each run of envelope between manholes shall be poured in one continuous operation. Where more than one pour is necessary, each pour shall terminate in a vertical plane, and 3/4-inch reinforcing rod dowel extending 18 inches into the concrete on each side of the joint shall be provided. The number and locations of dowels shall be as approved. Partial pours shall not terminate in horizontal or angular planes.
- L. Extensive Disturbed Earth: Where an envelope is installed over an extensive area of disturbed earth, such as that within the periphery of the building, a separate 3,000 psi concrete base, satisfactory, shall be provided to ensure stability of the conduits during installation. The base shall be allowed to set before the conduit bank is installed.
- M. Obstructions Below Grade: Where an envelope is installed over disturbed earth, across other conduits or pipe lines or under roads or driveways, it shall be reinforced. Reinforcement shall also be provided where envelopes connect to manhole and building walls, to prevent shearing of the joints. Where envelopes are terminated for future extension, dowels shall be provided as specified above for joints between pours. Reinforcement, generally, shall consist of 3/4-inch rods located in a single layer 1-1/2 inches above the bottom of the envelope. Outside rods shall be located 1-1/2 inches in from the outside edges of the envelopes and an intermediate rod shall be placed in the center of each space between conduits in the lowest row. Provide No. 4 steel reinforcing bars in top of envelope under paved areas. Additional reinforcement shall be furnished as directed following an inspection of the trench.
- N. Sub-Ups: Use rigid steel conduit for stub-ups to equipment. For equipment mounted on outdoor concrete pads, extend steel conduit a minimum of 5 feet (1.5m) from the edge of the pad and 5 feet outside of the building foundation. Install insulated grounding bushings on the terminations. Couple steel conduits to the ducts with adapters designed for the purpose and then encase coupling with 3 inches (75 mm) of concrete. Provide insulated grounding bushings on the terminations.

- O. Above-Grade Conduit:
1. All exposed conduit rising more than one foot (1') above the adjacent grade shall be rigid steel conduit, full weight, pipe size, finished inside and outside by a hot-dipped galvanized method. Conduit shall have threaded-type couplings and fittings with insulated end bushing. Rigid steel conduit shall extend a minimum of eighteen inches (18-inches) below grade before transition to PVC conduit.
 2. Provide galvanized or cadmium-plated nails, screws, clips, or other means of securely anchoring conduit to buildings or other structures as required for a complete installation. Adequate provisions shall be taken to prevent dielectric action between dissimilar metals.
- P. Sealing: Provide temporary closure at terminations of ducts that are wired under this project. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15 psi (1.03 Mpa) hydrostatic pressure.
- Q. Building Entrances: Transition from underground duct to conduit 1 foot (300 mm) minimum outside the building wall. Use fittings manufactured for the purpose. Follow appropriate installation instructions below.
1. Concrete-Encased Ducts: Install reinforcing in ductbanks passing through disturbed earth near buildings and other excavations. Coordinate ductbank with structural design to support ductbank at wall without reducing structural or watertight integrity of building wall.
 2. Waterproofed Wall and Floor Entrances: Install a watertight entrance-sealing device with the sealing gland assembly on the inside. Anchor device into masonry construction with 1 or more integral flanges. Secure membrane waterproofing of the device to make permanently watertight.
- R. Mandrelling: After concrete envelopes have set, all conduits shall be mandrelled to ensure smooth interior surfaces free from burrs or obstructions that might damage the conductor insulation or sheaths.

3.7 CONDUIT AND DUCT INSTALLATION

- A. Install nonmetallic conduit and duct as indicated according to Manufacturer's written instructions.
- B. Slope: Pitch ducts a minimum of 4 inches per 100 feet (1:300) to drain toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions. Trenches shall be evenly graded so that conduits will have a uniform rate of fall of not less than 3 inches per 100 feet and will be free from either horizontal or vertical waves. Unless otherwise specified, each conduit shall slope uniformly from one manhole to the next or from a high point between manholes. Low points between manholes or between upturned elbows, shall be avoided wherever possible. Where it is not possible to avoid a trap or low point in a conduit which has no concrete envelope, provide a 1/2-inch hole drilled in the bottom of the conduit at the low point and a crushed stone sump of suitable volume below the conduit. If possible, install the sump above the high water table elevation for the particular location. Otherwise, provide special means to prevent the accumulation of water within the conduit.

- C. Curves and Bends: Use manufactured elbows for stub-ups at equipment and at building entrances. Use manufactured long sweep bends with a minimum radius of 50 feet (15 m) both horizontally and vertically at other locations.
- D. Make joints in ducts and fittings watertight according to manufacturer's instructions. Stagger couplings so those of adjacent ducts do not lie in the same plane.
- E. Installation of warning tapes: After lacing a minimum of 12 –inches or a maximum of 18 inches of backfill over the ducts, place the appropriate warning tapes above and parallel to the centerline of the duct for the entire length of the duct trench.
- F. Provide pull rope and measuring tape shall be installed at the time the mandrel is pulled through each conduit. Record the wall-to-wall measurements and the size of mandrel used at this time. Provide this documentation to the Project Engineer on the following working day. After acceptance of these documents, the Contractor shall remove the measuring tape, leaving only the pull rope in the conduits.
- G. All work and materials covered by these Specifications shall be subject to inspection at times by the Owner's designated representative. Any work concealed before it has been inspected by the Owner's designated representative shall be re-opened or uncovered and any required modification made to that portion of the work. All trenches shall be opened from manhole to manhole or manhole to building prior to laying conduit in that trench. Exceptions (such as street crossings) will be approved prior to excavation on a case-by-case basis by the Owner at a regular project meeting. These sites shall be inspected by the Owner's representative during excavation, installation, backfill, restoration, and clean-up.
- H. Separation distance from other buried utilities as follows:
 - 1. Insulated Steam: 24-inches.
 - 2. Un-insulated Steam: 48-inches.
 - 3. All others: 18-inches.

3.8 DIRECT BURIED CONDUIT

- A. Provide where indicated direct-buried electrical circuits utilizing either PVC Schedule 40 or PVC-coated rigid galvanized steel conduit, as indicated. Conduit shall be as specified in Division 26 Section "Raceways and Boxes". Burial depth shall be as follows:
 - 1. Below paved roads (PVC and RGS): 30-inches below bottom of paving.
 - 2. Under non-vehicle concrete (PVC and RGS): 24-inches below bottom of paving.
 - 3. Other areas (PVC): 24-inches.
 - 4. Other areas (RGS): 24-inches.
- B. Minimum separation from other utilities shall be the same as for ductbanks, specified previously in this Section.
- C. Where feasible, and where indicated, install direct-buried lines parallel, but separated from other utility lines. Group several direct-buried conduits in a common trench where running in the same direction, or to/from the same source. All direct-buried conduits shall have yellow

plastic warning tape buried midway between the conduit and finished grade. Tape shall be the same as used for ductbanks.

- D. Where direct-buried conduits penetrate walls or floor slabs, seal all spaces around conduit and fittings. Provide through-wall fittings on all wall penetrations.
- E. Where an underground conduit, without a concrete envelope, enters the building through a non-waterproofed wall or floor, provide a sleeve made of Schedule 40 galvanized pipe. The space between the conduit and the sleeve shall be filled with a suitable plastic expansible compound or an oakum and lead joint on each side of the wall or floor in such a manner as to prevent entrance of moisture. A watertight entrance sealing device hereinbefore specified will be acceptable in lieu of the sleeve.

3.9 RECORD DOCUMENTS

- A. Provide record set data of the actual elevation of the top of each end of each raceway or ductbank at the midpoint, at no more than 100 foot intervals, where changes in elevation are less than 2 feet between data points, or 10 foot intervals when the elevation between intervals is different by 2 feet or more between data points.
- B. Provide record drawings indicating actual locations of all installed ductbanks and manholes including elevations. The record drawing shall indicate location, elevation, and type of service for all utilities crossed by new ductbank.
- C. Cable Records: The Contractor shall provide a complete listing of all cables installed in each conduit and ductbank, along with all cable splice locations.

3.10 FIELD QUALITY CONTROL

- A. Field inspection and testing shall be performed under provisions of Division 26 Section 260500, *Common Work Results for Electrical* in the presence of the Engineer.
- B. Backfilling shall not be done until the concrete has cured for at least three calendar days.
- C. Exposed surfaces of concrete shall be kept wet (damp) throughout the curing period.
- D. Upon completion of the duct bank installation, a standard flexible mandrel shall be pulled through each duct to loosen particles of earth, sand, or foreign material left in the line. The mandrel shall be not less than 12 inches long, and shall have a diameter 1/4-inch less than the inside diameter of the duct. A brush with stiff bristles shall then be pulled through each duct to remove the loosened particles. The diameter of the brush shall be the same as, or slightly larger than, the diameter of the duct.
- E. Seal the ducts and conduits at building entrances, and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of moisture and gases.

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DIVISION 26 SECTION 26 05 53
ELECTRICAL IDENTIFICATION
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SECTION 26 05 53 - ELECTRICAL IDENTIFICATION

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 Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and authorities having jurisdiction.
- B. This section includes labeling of all terminations and related subsystems; including, but not limited to, nameplates, stenciling, wire and cable markers, labeling and identification of cables, equipment and other products.

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Schedule of Nomenclature: An index of electrical equipment and system components used in identification signs and labels. Provide a schedule of nameplates and stenciling.
- C. Samples: Prior to installation, submit samples for each type of label and sign to illustrate color, lettering style, and graphic features of identification products. These samples shall include examples of the lettering to be used. Samples shall be mounted on 8-1/2-inch x 11-inch sheets annotated, explaining their proposed use.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with ANSI A13.1 and NFPA 70 for color-coding.
- D. Comply with applicable EIA/TIA Standards.
- E. Comply with OSHA Standards.

1.5 DEFINITIONS

- A. Emergency systems include, but are not limited to, generator circuits and systems, fire alarm systems, exit sign circuits, emergency lighting circuits, etc.

PART 2 - PRODUCTS

2.1 RACEWAY AND CABLE LABELS

- A. Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
 - 1. Color: Black letters on orange field.
 - 2. Legend: Indicates voltage and service.
- B. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl with legends, overlaminated with a clear, weather- and chemical-resistant coating.
- C. Pretensioned, Wraparound Plastic Sleeves: Flexible, preprinted, colored acrylic band sized to suit the diameter of the line it identifies and arranged to stay in place by pretensioned gripping action when placed in position.
- D. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 1/16 inch thick by 1 to 2 inches wide (0.08 mm thick by 25 to 51 mm wide), in appropriate colors for system voltage and phase.
- E. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.
- F. Aluminum, Wraparound Marker Bands: Bands cut from 0.014-inch- (0.4-mm-) thick aluminum sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.
- G. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.
- H. Aluminum-Faced, Card-Stock Tags: Weather-resistant, 18-point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inch (0.05 mm) thick, laminated with moisture-resistant acrylic adhesive, punched for fasteners, and preprinted with legends to suit each application.
- I. Brass or Aluminum Tags: 2 by 2 by 0.05-inch (51 by 51 by 1.3-mm) metal tags with stamped legend, punched for fastener.

2.2 NAMEPLATES AND SIGNS

- A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

- B. Engraved Plastic Nameplates and Signs: Engraving stock, melamine 3-layer plastic laminate, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes. Use colors prescribed by ANSI A13.1, NFPA 70 and these specifications.
 - 1. Engraved legend with white letters on black background.
 - 2. Emergency system nameplates shall have an engraved legend with white letters on red background, or as required by the local authority having jurisdiction.
- C. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch (6.4-mm) grommets in corners for mounting. Backed with adhesive material formulated for the type of surface and intended use.
- D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, non-fading, preprinted cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for the application. 1/4-inch (6.4-mm) grommets in corners for mounting.
- E. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws and No. 10 stainless-steel machine screws with nuts and flat and lock washers.

2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, one-piece self-locking, Type 6/6 nylon cable ties.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength: 50 lb (22.3 kg) minimum.
 - 3. Temperature Range: Minus 40 to plus 180 deg F (minus 40 to plus 85 deg C).
 - 4. Color: According to color-coding.
- B. Paint: Formulated for the type of surface and intended use.
 - 1. Primer for Galvanized Metal: Single-component acrylic formulated for galvanized surfaces.
 - 2. Primer for Concrete Masonry Units: Heavy-duty-resin block filler.
 - 3. Primer for Concrete: Clear, alkali resistant, binder-type sealer.
 - 4. Enamel: Silicon alkyd or alkyd urethane as recommended by primer manufacturer.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Identification
 - 1. Where mixed voltages are used in one building (e.g., 11,847 volts, 480 volts, 208 volts), each switch, switchboard, junction box, equipment, etc., on each system must be labeled for voltage in addition to other requirements listed herein.
 - 2. All branch circuit panelboards must be identified with the same designation used in the circuit directory in the Main Switchboard, and in Distribution Panelboards.

3. Before attaching labels, clean all surfaces with the label manufacturer's recommended cleaning agent.
 4. Install all labels firmly, as recommended by the label manufacturer.
 5. Labels attached to receptacle and switch faceplates shall be installed plumb and neatly on all equipment.
 6. Install nameplates parallel to equipment lines.
 7. Secure nameplates to equipment fronts using screws or rivets. Secure nameplate to inside of recessed panelboards in finished locations.
 8. Embossed tape will not be permitted for any application.
 9. Labels: All labels shall be permanent and be machine-generated. NO HANDWRITTEN OR NON-PERMANENT LABELS SHALL BE ALLOWED.
 10. Label size shall be appropriate for the conductor and cable size(s) and outlet faceplate layout. All labels to be used shall be self-laminating, white/transparent vinyl and be wrapped around the cable sheath. Flag type labels are not allowed. The labels shall be of adequate size to accommodate the circumference of the cable being labeled and properly self-laminated over the full extent of the printed area of the label.
- B. Panelboard Directories:
1. Panelboards shall be equipped with equipment nameplates as specified in paragraph "Equipment Identifications Labels" in Part 3 of this Section.
 2. Panelboards shall have an accurate typed index indicating exactly what each added branch serves.
 3. The Contractor shall provide up to date directories in new and existing panelboards, indicating all deletions and additions, and to note the date of all changes on the directory.
 4. The directory shall reflect the exact circuit designations. Directories indicating the reference room numbers on the contract drawings or in the panelboard schedule shall not be acceptable.
 5. If at anytime after occupancy the directory is found to be incorrect due to negligence by the installer, then the Contractor shall troubleshoot circuits, and correct the directory at no additional cost to the Owner.
- C. Miscellaneous Identification:
1. Individual circuit breakers, switches, and motor starters in panelboards and switchboards, and in motor control centers: 1/4-inch (6 mm); identify circuit and load served, including location.
 2. Individual circuit breakers, enclosed switches, and motor starters: 1/4-inch (6 mm); identify load served.
 3. Junction boxes: 1/2-inch (13 mm); identify system source(s) and load(s) served.
- D. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
- E. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.
- F. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.

- G. Self-Adhesive Identification Products: Clean surfaces before applying.
- H. Install painted identification according to manufacturer's written instructions and as follows:
1. Clean surfaces of dust, loose material, and oily films before painting.
 2. Prime surfaces using type of primer specified for surface.
 3. Apply one intermediate and one finish coat of enamel.
- I. Color Code Banding and Painting of Raceways, Boxes, and Cables: Band all exposed and concealed accessible raceways, pull boxes, and junction boxes of the systems listed below:
1. Bands: Pre-tensioned, wraparound plastic sleeves; colored adhesive tape; or a combination of both. Make each color band 2 inches (51 mm) wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
 2. Band Locations: At changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
 3. Junction boxes, pull boxes, and their covers shall be distinctively painted to identify their service.
 4. Apply the following colors to the systems listed below:
 - a. Fire Alarm System: Red.
 - b. Fire-Suppression Supervisory and Control System: Red and yellow.
 - c. Combined Fire Alarm and Security System: Red and blue.
 - d. Security System: Blue.
 - e. CCTV System: Green and yellow.
 - f. Mechanical and Electrical Supervisory System: Green and blue.
 - g. Telecommunication System: Green.
 - h. CATV System: Violet.
 - i. Computer Data: Blue.
 - j. 120/208 V (or 120/240 V) Power and Lighting System: Yellow.
 - k. 480/277 V Power and Lighting System: Black.
 - l. Standby/Emergency Power System: Orange.
 - m. Any other system, with system type (such as *Sound System*) marked on covers in black letters with white covers.
- J. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover. Install label on inside face of door or cover in finished spaces.
- K. Circuit Identification Labels on Boxes: Install labels externally.
1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
 2. Concealed Boxes: Plasticized card-stock tags.
 3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
- L. Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground line warning tape located directly above line at 12 inches (150 to 200 mm) below finished grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches (400 mm)

overall, use a single line marker. Install line marker for underground wiring, both direct-buried cables and cables in raceway.

- M. Secondary Service, Feeder, and Branch-Circuit Conductors: Color-code throughout the secondary electrical system. Refer to Division 26 Section 260519, *Conductors and Cables* for additional requirements.
- N. Power-Circuit and Control Wire Identification: Metal tags or aluminum, wraparound marker bands for each conductor, cables, feeders, and power circuits in vaults, panelboard gutters, outlet boxes, junction boxes, pullboxes, junction boxes, manholes, switchboard rooms, and at load connections. Identify with branch circuit or feeder number for power and lighting circuits and with control wire number as indicated on equipment manufacturer's shop drawings for control wiring.
1. Legend: 1/4-inch- (6.4-mm-) steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
 2. Tag Fasteners: Nylon cable ties.
 3. Band Fasteners: Integral ears.
- O. Apply identification to conductors as follows:
1. Conductors to be Extended in the Future: Indicate source and circuit numbers.
 2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
 3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.
- P. Apply warning, caution, and instruction signs as follows:
1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
 2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch- (9-mm-) high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.
- Q. Equipment Identification Labels: Engraved plastic laminate with white lettering on black background. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise noted, labels/nameplates shall include equipment designation(s), voltage rating, and source (including source locations). Labels for disconnect switches, motor starters, etc..., shall indicate the designation of the load served as the "equipment designation". In general, labels requiring one or two lines of text shall be 1-1/2 inches high. Labels requiring three lines of text shall be 2 inches high. The first line of text, which shall indicate equipment designation/load served, shall utilize 1/2 inch high lettering. Remaining

lines of text, which shall indicate voltage ratings and source information shall utilize ¼ inch high lettering. Refer to the Drawings for labeling examples. Apply labels to each unit of the following categories of equipment using mechanical fasteners:

1. Panelboards.
2. Switchboards.
3. Transformers.
4. Disconnect Switches.
5. Enclosed Circuit Breakers.
6. Motor Starters.
7. Push-Button Stations.
8. Contactors.
9. Electrical Cabinets and Enclosures.
10. Control Devices.
11. Fire Alarm Master Station or Control Panel.
12. Security-Monitoring Master Station or Control Panel.
13. Access Doors and Panels for Concealed Electrical Items.

R. Conduits Containing Electrical Feeders:

1. All conduits containing electrical feeders shall be identified with W.H. Brady B-500 vinyl cloth pipe markers or equivalent. Systems shall be identified as follows:
 - a. Labels shall be applied whenever a conduit enters or leaves a switchboard, panelboard, or a junction or pull box and at each side of penetrations of walls or floors.
 - b. Apply Y-35 series individual numbers and letters to indicate feeder number followed by feeder voltage.
 - c. At each end of the above series of markers provide a pipe banding tape around the conduit. Refer to paragraph Color Code Banding and Painting of Section 260533, *Raceways, Boxes, and Cables*, in part 3 of this Section for banding requirements.

S. Communication Conduit and Cables.

1. Cables shall be identified with Brady B-500 vinyl cloth markers or equivalent by L.E.M., Stranco, or Panduit wire markers. Conduit shall be identified with Brady Vinyl Cloth B-500 pipe markers or equivalent. Systems shall be identified as follows:
 - a. Each cable shall be identified at each point of entrance to or exit from a conduit or enclosure and at 50-foot intervals in the tray. All identification at 50-foot intervals shall be at the same location in the tray. Each cable shall be identified at control panels, junction boxes, and terminal boards.
Conduit shall be identified exiting an enclosure or panel at junction or pull boxes, and at each side of penetrations of walls, partitions, or floors, within 1-foot of penetration, to identify service type, i.e. "TELEPHONE", "DATA", "CATV", etc...

- T. Fire Alarm: Junction box covers shall be painted red and labeled "Fire Alarm" per NFPA 72. Wiring color code shall be as follows:
1. Red - Smoke Detector - Common.
 2. Black - Smoke Detector - Power.
 3. Yellow - Smoke Detector - Alarm.
 4. Orange - Heat Detector - Alarm.
 5. Pink - Flow Switch.
 6. Tan - Valve Tamper Switch.
 7. Purple - Bells.
 8. Grey - Audio/Visual Devices.
 9. Light Blue - Manual Stations.
- U. Provide NEC, ANSI, and OSHA-approved *DANGER - HIGH VOLTAGE* warning sign on all doors of dedicated electrical rooms or closets. Where doors are located in finished areas, locate sign on the inside of the door. Coordinate mounting requirements with the Engineer. Minimum sign dimension shall be 15-inch x 11-inch.
- V. Surfaces shall be cleaned and painted, if specified, before applying markings.
- W. Place markings so that they are visible from the floor.
- X. Protect finished identification to ensure that markings are clear and legible when project is turned over to the Owner.

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DIVISION 26 SECTION 26 05 73
SHORT CIRCUIT ANALYSIS, COORDINATION STUDY,
AND ARC FLASH HAZARD ANALYSIS
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SECTION 26 05 73 – SHORT CIRCUIT ANALYSIS, COORDINATION STUDY,
AND ARC FLASH HAZARD ANALYSIS

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 ALLOWANCES

- A. Refer to Division 01 Section, "Allowances" for description of work under this Section affected by Allowances.

1.3 SCOPE

- A. An Engineering Analysis and Coordination Study shall be performed on and include all portion of the electrical distribution system. The analysis shall include a short-circuit analysis with protective device evaluation, a protective device coordination study, time-current analysis of each protective device, and equipment evaluation study.
- B. The contractor shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in the current version of NFPA 70E – *Standard for Electrical Safety in the Workplace*. The arc flash hazard analysis shall be performed according to the IEEE Standard 1584-2002, the IEEE *Guide for Performing Arc-Flash Calculations*.
- C. The project/report shall begin at the new electric service and continue through the 480/277V and 208/120V distribution systems to the new branch panelboards, including dry-type transformers.

1.4 REFERENCES

- A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems.
 2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
 3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis.

4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings.
5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
6. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations.

B. American National Standards Institute (ANSI):

1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures.
3. ANSI C37.010 – Standard Application Guide for AC High Voltage Power Circuit Breakers Rated on a Symmetrical Current Basis.
4. ANSI C37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.

C. The National Fire Protection Association (NFPA)

1. NFPA 70 – National Electrical Code, latest edition.
2. NFPA 70E – Standard for Electrical Safety in the Workplace.

1.5 SUBMITTALS

- A. The studies shall be submitted to the Engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the study may cause delays in equipment shipments, approval from the Engineer may be obtained for a preliminary submittal of data to ensure that the selection of device ratings and characteristics will be satisfactory to properly select the distribution equipment. The formal study will be provided to verify preliminary findings.
- B. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. A minimum of five (5) bound copies of the complete final report shall be submitted. Electronic PDF copies of the report shall be provided upon request.
- C. The report shall include the following sections:
 1. Executive Summary including Introduction, Scope of Work and Results/Recommendations.
 2. Short-Circuit Methodology Analysis Results and Recommendations.
 3. Short-Circuit Device Evaluation Table
 4. Protective Device Coordination Methodology Analysis Results and Recommendations.
 5. Protective Device Settings Table
 6. Time-Current Coordination Graphs and Recommendations
 7. Arc Flash Hazard Methodology Analysis Results and Recommendations including the details of the incident energy and flash protection boundary calculations, along with Arc Flash boundary distances, working distances, Incident Energy levels and Personal Protection Equipment levels.

8. Arc Flash Labeling section showing types of labels to be provided. Section will contain descriptive information as well as typical label images.
 9. One-line system diagram that shall be computer generated and will clearly identify individual equipment buses, bus numbers used in the short circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location, device numbers used in the time-current coordination analysis, and other information pertinent to the computer analysis.
- D. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include list of completed projects with project names, addresses, names of Engineer and Owner, and other information specified.

1.6 QUALITY ASSURANCE

- A. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the responsible charge and approval of a Registered State of Delaware Professional Electrical Engineer skilled in performing and interpreting the power system studies. Report shall be signed and sealed by the Engineer.
- B. The Registered Professional Electrical Engineer shall have a minimum of five (5) years of experience in performing power system studies.
- C. The approved engineering firm shall demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual arc flash hazard analyses it has performed in the past year.
- D. Engineering Analysis and Coordination study shall be performed by Coordinated Power Engineering, Inc., or an approved and qualified equal.
 1. Cable Testing Services, Inc.
1212 Calvert Road
North East, MD 21901
Telephone: 410-366-5420
Toll-Free: 1-800-824-6600
Fax: 410-366-7515
Contact: Charles Emery, PE
 2. AB Engineering LLC
305 Dressage Court
West Chester, PA 19382
Telephone: 610-765-1290
Contact: Alton Baum, PE

3. Potomac Testing, Inc.
1610 Professional Blvd, Suite A
Crofton, MD 21114
Telephone: 301-352-1930
Toll-Free: 1-800-331-2022
Contact: John F. Mayan, PE
4. Coordinated Power Engineering, Inc.
1340-G Charwood Road
Hanover, MD 21076
Telephone: 410-694-9494
Fax: 410-694-0085
Contact: Carl E. Rager, PE

PART 2 - PRODUCTS

2.1 STUDIES

- A. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E – Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D. This study shall also include short-circuit and protective device coordination studies.

2.2 DATA

- A. Contractor shall furnish all data as required for the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with existing or required data immediately after award of the contract. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.
- B. Source combination may include present and future motors.
- C. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner or Contractor.
- D. If applicable, include fault contribution of existing motors in the study. The contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

2.3 SHORT-CIRCUIT ANALYSIS

- A. Transformer design impedances shall be used when test impedances are not available.

- B. Provide the following:
1. Calculation methods and assumptions
 2. Selected base per unit quantities.
 3. One-line diagram of the system being evaluated that clearly identifies individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location and other information pertinent to the computer analysis.
 4. The study shall include input circuit data including electric utility system characteristics, source impedance data, conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other circuit information as related to the short-circuit calculations.
 5. Tabulations of calculated quantities including short-circuit currents, X/R ratios, equipment short circuit interrupting or withstand current ratings and notes regarding adequacy or inadequacy of the equipment rating.
 6. Results, conclusions, and recommendations. A comprehensive discussion selection evaluating the adequacy or inadequacy of the equipment must be provided and include recommendations as appropriate for improvements to the system.
- C. For solidly-grounded systems, provide a bolted line-to-ground fault current study for applicable buses as determined by the engineer performing the study.
- D. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to short circuit ratings.
 2. Adequacy of switchgear, motor control center and panelboard bus bars to withstand short-circuit stresses.
 3. Contractor shall notify Engineer in writing, of any circuit protective devices improperly rated for the calculated available fault current.

2.4 PROTECTIVE DEVICE TIME-CURRENT COORDINATION ANALYSIS

- A. Protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs.
- B. Include on each TCC graph, a complete title with descriptive device names.
- C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
- D. Identify the device associated with each curve by manufacturer type, function, and, if applicable, time delay, and instantaneous settings recommended.
- E. Plot the following characteristics on the TCC graphs, where applicable.
1. Electric utility's overcurrent protective device
 2. Medium voltage equipment overcurrent relays

3. Medium and low voltage fuses including manufacturer's minimum emtl, total clearing, tolerance, and damage bands.
 4. Low-voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
 5. Transformer full load current, magnetizing inrush current, and ANSI through fault protection curves.
 6. Medium voltage conductor damage curves.
 7. Ground fault protective devices, as applicable.
 8. Pertinent motor starting characteristics and motor damage points, where applicable.
 9. The largest feeder circuit breaker in each applicable panelboard.
- F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.
- G. Provide the following:
1. A one-line diagram shall be provided which clearly identifies individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus when known.
 2. A sufficient number of log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices and other pertinent system parameters.
 3. Computer printouts shall accompany the log-log plots and will contain descriptions for each of the devices shown, settings of the adjustable device, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.
 4. The study shall include a separate, trouble printout containing the recommended settings of all adjustable overcurrent protective devices, the equipment designation where the devices is located, and the device number corresponding to the device on the system one-line diagram
 5. A discussion section which evaluates the degree of system protection and service continuity with overcurrent devices, along with recommendations as required for addressing system protection or device coordination deficiencies.
 6. Contractor shall notify Engineer in writing of any significant deficiencies in protection and /or coordination. Provide recommendations for improvements.

2.5 ARC FLASH HAZARD ANALYSIS

- A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA 70E-2009, Annex D. The arc flash hazard analysis shall be performed in conjunction with the short-circuit analysis (Section 2.03) and the protective device time-current coordination analysis (Section 2.04).
- B. The flash protection boundary and the incident energy shall be calculated at all locations in the electrical distribution system (distribution panelboard, branch panelboards) where work could be performed on energized parts.
- C. Working distances shall be based on IEEE 1584. The calculated arc flash protection boundary shall be determined using those working distances.

- D. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.
- E. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location in a single table. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum. Conversely, the maximum calculation will assume a maximum contribution from the utility. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable as well as any stand-by generator applications.
- F. The Arc-Flash Hazard Analysis shall be performed utilizing mutually agreed upon facility operational conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.
- G. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions as the sources are interrupted or decremented with time. Fault contribution from motors should be decremented as follows:
1. Fault contribution from induction motors should not be considered beyond 5 cycles.
- H. For each piece of ANSI rated equipment with an enclosure main device, two calculations shall be made. A calculation shall be made for the main cubicle, sides or rear; and shall be based on a device located upstream of the equipment to clear the arcing fault. A second calculation shall be made for the front cubicles and shall be based on the equipment's main device to clear the arcing fault. For all other non-ANSI rated equipment, only one calculation shall be required and it shall be based on a device located upstream of the equipment to clear the arcing fault.
- I. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.
- J. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.
- K. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. A minimum clearing time of 2 seconds will be used based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.
- L. Provide the following:

1. Results of the Arc-Flash Hazard Analysis shall be submitted to tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, working distances, personal protective equipment classes and AFIE (Arc Flash Incident Energy) levels.
2. The Arc Flash Hazard Analysis shall report incident energy values based on recommended device setting for equipment within the scope of the study.
3. The Arc-Flash Hazard Analysis may include recommendations to reduce AFIE levels and enhance worker safety.

PART 3 - EXECUTION

3.1 FIELD ADJUSTMENT

- A. Contractor shall adjust relay and protective device settings according to the recommended setting table provided by the coordination study.
- B. Contractor shall make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
- C. Contractor shall notify Engineer in writing of any required major equipment modifications.

3.2 ARC FLASH LABELS

- A. Contractor shall provide a 4.0 in. x 4.0 in. Brady thermal transfer type label of high adhesion polyester for each work location analyzed.
- B. The labels shall be designed according to the following standards:
 1. UL969 – Standard for Marking and Labeling Systems
 2. ANSI Z535.4 – Product Safety Signs and Labels
 3. NFPA 70 (National Electrical Code) – Article 110.16
- C. The labels shall include the following information:
 1. System Voltage
 2. Flash Protection boundary
 3. Personal Protective Equipment category
 4. Arc Flash Incident energy value (cal/cm²)
 5. Limited, restricted, and prohibited Approach Boundaries
 6. Report number and issue date
- D. Labels shall be printed by a thermal transfer type printer, with no field markings.
- E. Arc flash labels shall be provided for equipment as identified in the study and the respective equipment access areas per the following:

1. Floor Standing Equipment – Labels shall be provided on the front of each individual section. Equipment requiring rear and/or side access shall have labels provided on each individual section access area. Equipment line-ups containing sections with multiple incident energy and flash protection boundaries shall be labeled as identified in the Arc Flash Analysis table.
2. Wall Mounted Equipment – Labels shall be provided on the front cover of a nearby adjacent surface, depending upon equipment configuration.
3. General Use Safety labels shall be installed on equipment in coordination with the Arc Flash labels. The General Use Safety labels shall warn of general electrical hazards associated with shock, arc flash, and explosions, and instruct workers to turn off power prior to work.

F. Labels shall be field installed by Contractor.

3.3 ARC FLASH TRAINING

- A. The vendor supplying the Arc Flash Hazard Analysis shall train the Owner's qualified electrical personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). The trainer shall be an authorized OSHA Outreach instructor.
- B. The vendor supplying the Arc Flash Hazard Analysis shall offer instructor led and online NFPA 70E training classes.

3.4 AVAILABLE FAULT CURRENT LABELING

- A. Contractor shall provide a 4.0 in. x 4.0 in. Brady thermal transfer type label of high adhesion polyester for each work location analyzed.
- B. The labels shall be designed according to the following standards:
 1. UL969 – Standard for Marking and Labeling Systems
 2. ANSI Z535.4 – Product Safety Signs and Labels
 3. NFPA 70 (National Electrical Code) – Article 110.24.
- C. The labels shall include the following information:
 1. Line 1 – “Maximum Available Fault Current”
 2. Line 2 – “_____ Amperes”; Contractor shall field mark maximum available fault current available at the line terminals of the equipment.
 3. Line 3 – Date of Installation

- D. Labels shall be printed by a thermal transfer type printer.
- E. Labels shall be field-installed by the Contractor.

END OF SECTION

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DIVISION 26 SECTION 26 09 23
LIGHTING CONTROL DEVICES
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SECTION 26 09 23 - LIGHTING CONTROL DEVICES

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. Provide lighting controls that can operate as standalone local room network(s) and have the capability to expand to a central building wide network. The building wide network shall provide control, monitoring, adjustment and scheduling functionality. The system shall be network based with software and historical data storage. The system shall support third party integration with the building management system through BACnet/IP.
- B. This Section includes the following lighting control devices:
 - 1. Time switches.
 - 2. Photoelectric switches.
 - 3. Daylight-harvesting controls.
 - 4. Indoor occupancy/vacancy sensors.
 - 5. Low voltage switches.
 - 6. Lighting contactors.
 - 7. Emergency shunt relays.
- C. Related Sections include the following:
 - 1. Division 26 Section 262726, *Switching Devices* for snap switches.
 - 2. Section 260943 "Network Lighting Controls".

1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. PIR: Passive infrared.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Coverage Plans: Provide full scale plans showing locations and coverage patterns for all occupancy/vacancy sensors.
- C. Location Plans: Provide full scale plans showing locations and coverage patterns for all devices.

- D. Shop Drawings: Show installation details for occupancy and light-level sensors.
 - 1. Interconnection diagrams showing field-installed wiring.
 - 2. Include diagrams for power, signal, and control wiring.
 - 3. Include riser diagrams showing all devices and wiring.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. 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.

1.6 SUBSTITUTIONS

- A. The lighting control specification and lighting control details represent the basis of design. Acceptable manufacturers must meet the criteria listed in the system requirements as well as intent demonstrated through control details. Compliant systems are required to achieve the design intent and are not required to have all the parts and pieces listed.
- B. Manufacturers not listed in the list of Acceptable Manufacturers must submit for approval within 10 days prior to bid.
- C. Acceptable Manufacturers
 - 1. Basis of Design
 - a. Acuity Brand Controls, Light.
 - 2. Alternative Manufacturers
 - a. Wattstopper; Digital Lighting Management
 - b. Hubbell NX
 - c. Eaton; Room Controller System

1.7 COORDINATION

- 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 system, and partition assemblies.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide a wired digital networked lighting control system as indicated on the drawings. The system shall include, but not be limited to, occupancy/vacancy sensor(s), photo sensor(s), digital room controller(s), digital switches, and all interconnecting wiring required for a complete operational system. The Basis-of-Design System is the Acuity Brand Controls; nLight.

2.2 TIME SWITCHES

- A. Basis-of-Design product: Subject to compliance with requirements, provide Acuity or a comparable product by one of the following:
1. Wattstopper.
 2. Leviton Manufacturing Company, Inc.
 3. Pass & Seymour.
 4. Cooper Industries, Inc.
 5. Intermatic, Inc.
- B. Digital Time Switches: Wall switch style, electroluminescent back-lit LED display shows timer countdown, time-out adjustments from 5 minutes to 12 hours, compatible with electronic ballasts; UL listed, five-year warranty.

2.3 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Acuity.
 2. Cooper Industries.
 3. Intermatic, Inc.
 4. NSi Industries, LLC; TORK Products.
 5. Tyco Electronics; ALI Brand.
- B. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773 A.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
 3. Time Delay: 15-second minimum, to prevent false operation.
 4. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.

5. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.4 LIGHTING CONTACTORS

- A. Basis of Design Product: Subject to compliance with requirements, provide ASCO; 918 series with solid-state control module for 2 wire control with number of poles and ratings as indicated on the drawing, or a comparable product by one of the following:
 1. Square D; Schneider Electric.
 2. Allen-Bradley/Rockwell Automation.
- B. Description: Electrically operated and mechanically held, combination type with non fused disconnect, 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 25 percent or less total harmonic distortion 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.
 4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.
- C. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.
 1. Monitoring: On-off status.
 2. Control: On-off operation.

2.5 DAYLIGHT-HARVESTING DIMMING CONTROLS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide nLight nCm ADCX RJB or comparable product by one of the following:
 1. Wattsopper DLM
 2. Hubbell NX
 3. Eaton
- B. System Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.
 1. Lighting control set point is based on two lighting conditions:
 - a. When no daylight is present (target level).
 - b. When significant daylight is present.

2. System programming is done with a hand held digital configuration tool or a PC with appropriate software.
 - a. Initial setup tool: a hand held digital configuration tool. Sensor adjustments may also be made using configuration pushbuttons on the sensors.
 - b. USB interface and PC software: capability to program, read, store, modify and document device and system configuration.
- C. Ceiling-Mounted Dimming Controls: Solid-state, digital light-level sensor unit, with separate controller unit, to detect changes in lighting levels that are perceived by the eye in order to automatically dim a lighting zone.
- D. Electrical Components, Devices, and Accessories:
 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency and marked for intended location and application.
 2. Operating Ambient Conditions: Dry interior conditions, 32 to 104 deg F (0 to 40 deg C).
 3. Sensor Output: Digitally communicates with room controller to dim loads based on lighting conditions. Sensor is powered from the room controller.
- E. Light-Level Sensor Set-Point Adjustment Range: 10 to 200 fc (108 - 2152 lux)

2.6 INDOOR OCCUPANCY/VACANCY SENSORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide nLight nCM PDT RJB, nWV PDT, or comparable product by one of the following:
 1. Wattstopper DLM
 2. Hubbell NX
 3. Eaton
- B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state digital indoor occupancy/vacancy sensors with a separate controller unit.
 1. Systems programming is done with a hand held digital configuration tool or a PC with appropriate software.
 - a. Initial setup tool: a hand held digital configuration tool. Sensor adjustments may also be made using configuration pushbuttons on the sensors.
 - b. USB interface and PC software: capability to program, read, store, modify and document device and system configuration.
 2. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 3. Operation:
 - a. Occupancy Sensor: Automatic-on when coverage area is occupied, and automatic-off when unoccupied.

- b. Vacancy Sensor: Manual-on when coverage area is occupied, and automatic-off when unoccupied.
 - c. Time Delay for turning lights off adjustable over a minimum range of 1 to 30 minutes in 1-minute increments. Default setting: 20 minutes.
 4. Sensor Output: Digitally communicates with room controller to turn loads on and off based on occupancy. Sensor is powered from the room controller.
 5. Mounting:
 - a. Sensor: Suitable for mounting, ceiling mounting and corner mounting.
 - b. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind removable cover.
 6. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
 - C. PIR Type: Ceiling mounted; detect occupants in coverage area by their head movement.
 1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
 2. Detection Coverage (Standard Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 3. Detection Coverage Large Room): Detect occupancy anywhere in a circular area of 2000 sq.ft. (186 sq.m) when mounted on a 96-inch-(2440-mm) high ceiling.
 - D. Ultrasonic/Microphonic Type: 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 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
 2. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 - E. Dual-Technology Type: 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- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
 3. Detection Coverage (Corridor): Detect occupancy anywhere within 48 feet (18.0 m) when mounted on a 10-foot- (3-m-) high ceiling in a corridor not wider than 12 feet (3.7 m).
 4. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 5. Detection Coverage (corner mount): Detect occupancy anywhere within a 30 foot (9145 mm) radius when corner mounted at ceiling or on wall at 120-inches (3058 mm) above the finished floor. Provide stem mount as required to maintain manufacturer's recommended mounting height.

2.7 SWITCHBOX-MOUNTED OCCUPANCY/VACANCY SENSORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Sensor Switch WSX, WSX-ZP, WSX-D (to match function indicated on the drawings) or comparable product by one of the following:
1. Wattstopper DLM
 2. Hubbell NX
 3. Eaton
- B. General Description: Wall-mounting, solid-state units suitable for mounting in a single-gang switchbox
1. Operation:
 - a. Occupancy Sensor: Automatic-on when coverage area is occupied, and automatic-off when unoccupied.
 - b. Vacancy Sensor: Manual-on when coverage area is occupied, and automatic-off when unoccupied.
 - c. Time Delay for turning lights off, adjustable over a minimum range of 1 to 30 minutes in 1-minute increments. Default setting: 15 minutes.
 2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A.
 3. Mounting:
 - a. Sensor: Suitable for mounting in a standard outlet box.
 - b. Time-Delay and Sensitivity Adjustments: Accessed and concealed.
 4. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 5. Bypass Switch: Override the on function in case of sensor failure.
 6. Automatic Light-Level Sense: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.
- C. Dual-Technology Type: Wall mounting; detect occupancy by using a combination of PIR and ultrasonic or microphonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: separate for each sensing technology.
 2. Detection Sensitivity: Detect occurrences of 6-inch (150 mm) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12-inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12-inches/s (305 mm/s).
 3. Detection Coverage: (Standard Room): Detect occupancy anywhere within a 15 foot radius (4572 mm) when wall mounted at 48-inches (1220 mm) above finished floor.

2.8 LOW VOLTAGE SWITCHES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide nLight PODM, or comparable product by one of the following:
1. Wattstopper DLM
 2. Hubbell NX
 3. Eaton
- B. General Description: Low-voltage, momentary pushbutton switches in 1, 2, 3, 4, 5, and 8 button configuration with the following features.
1. Two-way infrared (IR) transceiver for use with personal, and configuration remote controls.
 2. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
 3. Configuration LED on each switch that blinks to indicate data transmission.
 4. Load/Scene Status LED on each switch button with the following characteristics:
 - a. Bi-level LED
 - b. Dim locator level indicates power to switch
 - c. Bright status level indicates that load or scene is active
 5. Dimming switches shall include seven bi-level LEDs to indicate load levels using 14 steps.
- C. Two RJ-45 ports for connection to local network.
- D. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology local network. No additional configuration will be required to achieve multi-way switching.
- E. The following switch attributes may be changed or selected using a wireless configuration tool:
1. Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
 2. Individual button function may be configured to Toggle, On only, or Off only.
 3. Individual scenes may be locked to prevent unauthorized change.
 4. Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.
 5. Ramp rate may be adjusted for each dimmer switch.
 6. Switch buttons may be bound to any load on a room controller and are not load type dependent; each button may be bound to multiple loads.

2.9 DIGITAL ROOM CONTROLLERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide nLight nPP16 or comparable product by one of the following:
1. Wattstopper DLM
 2. Hubbell NX

3. Eaton
- B. Description: Self configuring, digitally addressable one, two or three relay controllers with 0-10 volt control for drivers and single relay application-specific plug load controllers (if applicable) Room controllers shall be provided to match room lighting load and control requirements and have the following features:
1. Automatic room configuration to the most energy-efficient sequence of operation based upon the devices in the room.
 2. Simple replacement – Using the default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf unit without requiring any configuration or setup.
 3. Device Status LEDs to indicate:
 - a. Data transmission.
 - b. Device has power.
 - c. Status for each load.
 - d. Configuration status.
 4. Quick installation features including:
 - a. Standard junction box mounting.
 - b. Quick low voltage connections using standard RJ-45 patch
 5. Plenum rated.
 6. Manual override and LED indication for each load.
 7. Dual voltage (120/277 VAC, 60 Hz)
 8. Zero cross circuitry for each load.
 9. Controllers shall be equipped for fail-safe operation and shall be evaluated for this purpose.
 10. Controllers shall be activated by activation of the building fire alarm system.
 11. Controllers shall be equipped for activation by the building security system.
- C. On/Off/Dimming enhanced room controller shall include:
1. Real time current monitoring.
 2. One, two or three relay configuration.
 3. Efficient 250mA switching power supply.
 4. Four RJ-45 local network ports.
 5. One 0-10 volt analog output per relay for control of compatible LED drivers.
 6. Optional Network Bridge for BACnet MS/TP communications (LMRC-3xx).
 7. The following dimming attributes may be changed or selected using a wireless configuration tool:
 - a. Establish preset level for each load from 0-100%.
 - b. Set high and low trim for each load.
 - c. Set lamp burn in time for each load up to 100 hours.
 8. Discrete model listed for connection to receptacles, for occupancy-based control of plug loads within the space.

- a. One relay configuration only.
- b. Automatic-ON/OFF configuration.

2.10 CONFIGURATION TOOL

- A. Basis-of-Design Product: Subject to compliance with requirements, provide nLight, or comparable products by one of the following:
 1. Wattstopper DLM
 2. Hubbell NX
 3. Eaton
- B. A configuration tool facilitates customization of local networks, and is used to set up open loop daylighting sensors. A wireless configuration tool features infrared communications, while PC software connects to each local network via a USB interface. Features and functionality of the wireless configuration tool shall include:
 1. Two-way infrared (IR) communication with IR-enabled device within a range of approximately 30 feet.
 2. High visibility organic LED (OLED) display, pushbutton user interface and menu-driven operation.
 3. Read, modify and send parameters for occupancy sensors, daylighting sensors, room controllers and buttons on digital wall switches.
 4. Save up to nine occupancy sensor setting profiles and apply profiles to selected sensors.
 5. Temporarily adjust light level of any load on the local network, and incorporate those levels in scene setting.
 6. Adjust or fine-tune daylighting settings established during auto-commissioning, and input light level data to complete commissioning of open loop daylighting controls.

2.11 EMERGENCY SHUNT RELAY

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Bodine or comparable product by one of the following:
 1. Lighting Control and Design, Inc.
 2. Nine Twenty Four
- B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 1008 and/or UL 924.
 1. Configuration: 120 / 277 V.

2.12 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section, Low-Voltage Electrical Power Conductors and Cables.

- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 24 AWG. Comply with requirements in Division 26 Section 260519, *Low-Voltage Electrical Power Conductors and Cables*.
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section 260519, *Low-Voltage Electrical Power Conductors and Cables*."

PART 3 - EXECUTION

3.1 PRE-INSTALLATION MEETING

- A. Convene minimum two weeks prior to commencing Work of this section. Meeting to be attended by Contractor, Owner's representative, system installer, factory authorized manufacturer's representative, and representative of all trades related to the system installation.
- B. Review installation procedures and coordination required with related Work and the following:
 - 1. Confirm the location and mounting of all devices, with special attention to placement of switches, dimmers, and any sensors.
 - 2. Review the specifications for low voltage control wiring and termination.
 - 3. Discuss the functionality and configuration of all products, including sequences of operation, per design requirements.
 - 4. Discuss requirements for integration with other systems.
- C. Inspect and make notes to job conditions prior to installation.
 - 1. Record minutes of the conference and provide copies to all parties present.
 - 2. Identify all outstanding issues in writing designating the responsible party for follow-up action and the timetable for completion.
 - 3. Installation shall not begin until all outstanding issues are resolved to the satisfaction of the Owner's representative.

3.2 SENSOR INSTALLATION

- 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 detector, fire suppression systems, and partition assemblies.
- 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 written instructions.

3.3 CONTACTOR INSTALLATION

- 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 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 Section 260519, *Low-Voltage Electrical Power Conductors and Cables*. Minimum conduit size shall be 1/2 inch (13 mm).
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.5 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section 260553, *Electrical Identification*.
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaries 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. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 2. Operational Test: Verify operation of each lighting control device, and adjust time delays.
- B. Lighting control devices that fail tests and inspections are defective work.
- C. Prepare test and inspection reports.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide assistance in adjusting sensors to suit 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.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section 017900, *Demonstration and Training*.

END OF SECTION

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DIVISION 26 SECTION 26 09 43
NETWORK LIGHTING CONTROLS
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SECTION 26 09 43 - NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

- A. The work covered in this section is subject to all of the requirements in the General Conditions of the Specifications. Contractor shall coordinate all of the work in this section with all of the trades covered in other sections of the specification to provide a complete and operable system. Provide all Labor, materials, appliances, tools, equipment, facilities, transportation and services necessary for and incidental to performing all operations in connection with furnishing, delivery and installation of the work of this Section.

1.2 DESCRIPTION OF WORK

- A. Furnish and install a complete system for the control of lighting and other equipment as indicated on the plans, detailed in the manufacturer submittal and as further defined herein. Contractor is solely responsible to verify quantity, installation locations and wiring requirements for this project. Specific manufacturer's catalog numbers, when listed in this section are for reference only. It is the responsibility of the contractor to verify with lighting control manufacturer all catalog information and specific product availability.
- B. The system shall include but not be limited to the following: Pre-wired, microprocessor controlled relay or dimming panels with lighting relays controlled via switches, photocells, occupancy sensors, time based control, building automation systems, thermostats, and other control devices.

1.3 SUBMITTALS

- A. Shop Drawings: Submit drawings of lighting control system and accessories including, but not necessarily limited to, relay panels, switches, occupancy sensors, photocells and other interfaces. Shop drawings shall indicate location of each device. Plans are diagrammatical. Electrical Contractor shall verify all lighting control material requirements from approved shop drawings. "Cut sheet" submittals not acceptable.
- B. Product Data: Submit for approval manufacturer's data for each type of product. Include construction details, descriptions, dimensions, and conductors and cables. Submit a complete bill of materials with part numbers, description and voltage specifications.
- C. One Line Diagram: Submit a one-line diagram of the system configuration indicating the type, size and number of conductors between each component. Submittals that show typical riser diagrams are not acceptable.
 - 1. Show installation details for all devices including interconnection diagrams showing all field installed wiring.
 - 2. Include diagrams for power, signal and control wiring.

- D. Coverage Plans: Show locations and coverage patterns for all occupancy sensors.
- E. Programming Forms: Submit programming forms with complete information describing the operation of the network lighting control system and all other information necessary to show proper operation of the system.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of lighting control device to include in emergency, operation and maintenance manuals.

1.6 SUBSTITUTIONS

- A. The lighting control specification and lighting control details represent the basis of design. Acceptable manufacturers must meet the criteria listed in the system requirements as well as intent demonstrated through control details. Compliant systems are required to achieve the design intent.
- B. Manufacturers not listed in the list of Acceptable Manufacturers must submit for approval within ten (10) days prior to bid.
- C. Acceptable Manufacturers
 - 1. Basis of Design
 - a. Acuity Brand Control nLight.
 - 2. Alternative Manufacturers
 - a. Watstoppe Digital Lighting Management.
 - b. Hubbell NX
 - c. Eaton Room Controller System.

PART 2 - PRODUCTS

2.1 GENERAL SYSTEM REQUIREMENTS

- A. System Architecture
 - 1. System shall have an architecture that is based upon wired networkable intelligent lighting control devices, standalone lighting control zones using distributed intelligence, and system backbone for remote, time based and global operation between control zones.

2. The system shall be capable of providing individually addressable switching and dimming control of the following: control zones to include multiple switch legs or circuits, relays and dimming outputs from centralized panels and networked luminaires. System shall be capable of integrating indoor and outdoor lighting controls.
3. Lighting control zones shall be capable of being networked with a higher level system backbone to provide time based control, remote control from inputs and/or systems external to the control zone, and remote configuration and monitoring through software.
4. System shall be capable of 'out of box' sequence of operation for each control zone. Standard Sequence is:
 - a. All switches control all power packs in a zone.
 - b. All occupancy sensors automatically control all power packs in the control zone with a default time out.

B. Wired Network Control Zone Characteristics

1. Following proper installation and provisions of power, all networked devices connected together with low voltage network cable shall automatically form a functional lighting control zone without requiring any type of programming. The 'out of box' default sequence of operation is intended to provide typical sequence of operation so as to minimize the system start up and programming requirements and to also have functional lighting control operation prior to system startup and programming.
2. System shall be able to automatically discover all connected devices without requiring any provisioning of system or zone address.

C. System Integration Capabilities

1. The system shall be capable of interface with third party building management systems to support two-way communication using the industry standard BACnet/IP or BACnet/MSTP protocols.

2.2 DISTRIBUTED SYSTEM POWER, SWITCHING AND DIMMING CONTROLS

- A. Devices shall incorporate one optional Class 1 relay, optional 0-10 VDC dimming output, and contribute low voltage class 2 power to the rest of the system.
- B. Device programming parameters shall be available and configurable remotely from the software and locally via the device push-button.
- C. Power packs shall accept 120 or 277 volt VAC and shall be plenum rated.
- D. Devices shall be UL listed for load and load types as specified on the plans.

2.3 WIRED NETWORK RELAY AND DIMMING PANEL

- A. Relays and dimming panels shall be capable of providing the required amount of relay capacity indicated as 4-relay, 8-relay, or 16-relay, as required per panel schedules shown on drawings, with an equal number of individually 0-10v dimming outputs.

- B. Standard relays used shall have the following required properties:
 - 1. Configurable in the field to operate with normally closed or normally open behavior.
 - 2. Provide visual status of current state and manual override control of each relay.
 - 3. Be individually programmable.
- C. 0-10 VDC dimming outputs shall support a minimum of 100 mA sink current per output.
- D. Panel shall be UL924 listed for control of emergency lighting circuits.
- E. Panel shall provide a contact closure input that acts as a panel override to activate the normally configured state of all relays in the panels.

2.4 WIRED NETWORKED WALL SWITCHES, DIMMERS, SCENE CONTROLLERS

- A. Wall switches & dimmers shall support the following device options:
 - 1. Number of control zones: 1, 2 or 4.
 - 2. Control Types Supported: On / Off or On / Off / Dimming
- B. Scene controllers shall support the following device options:
 - 1. Number of Scenes: 1, 2 or 4.
 - 2. Control Types Supported:
 - a. On / Off or On / Off / Dimming
 - b. Preset Level Scene Type
 - c. Reprogrammed or other devices withinaisy-chained zone so as to implement user selected lighting scene.
 - d. Selecting a lighting profile to run by the system's upstream controller so as to implement a selected lighting profile across multiple zones.

2.5 WIRED NETWORKED OCCUPANCY AND PHOTOSENSORS

- A. Sensors shall utilize passive infrared (PIR) or dual technology (microphonic/ultrasonic plus passive infrared) to detect both the major (walking) and minor (hand) motion as defined by NEMA WTJ-7 standards.
- B. Sensing technologies that are acoustically passive, meaning they do not transmit sound waves to any frequency, do not require commissioning. Ultrasonic based sensing technologies may require commissioning or sensitivity adjustment due to the active nature of their technology, if factory required.
- C. Sensor coverage shall be coordinated with the floor plans. Sensors shall be available in standard and extended range, as well as being available with option for High Bay mounting.
- D. Sensor programming parameter shall be available and configurable remotely from the software and locally via the device.

- E. Sensor mounting type shall match project design requirements as shown on the plans.
 - 1. Sensors shall have optional features for photosensor/daylight override, dimming control and low temperature/high humidity operations.
- F. The system shall support the following types of photocell-based control:
 - 1. On / Off: The control zone is automatically turned off if the photocell reading exceeds the defined setpoint and automatically turned on if the photocell reading is below the defined setpoint. A time delay or adaptive setpoint adjustable behavior may be used to prevent the system from exhibiting nuisance on/off switching.
 - 2. Continuous Dimming: The control zone automatically adjusts its dimming output in response to photocell readings, such that a minimum light level consisting of both electric light and daylight sources is maintained at the task. The photocell response shall be configurable to adjust the photocell setpoint and dimming rates.

2.6 WIRED NETWORKED AUXILIARY INPUT / OUTPUT (I/O) DEVICES

- A. Auxiliary Input / Output Devices shall be specified as an input or output device with the following options:
 - 1. Contact closure input
 - a. Input shall be programmable to support momentary or momentary inputs that can activate local or global scenes and profiles, ramp light level up or down, or toggle lights on/off.
 - 2. 0-10v analog input
 - a. Input shall be programmable to function as a daylight sensor.
 - 3. RS-232/RS-485 digital input
 - a. Input supports activation of up to 4 local or global scenes and profiles, and on/off/dimming control of up to 16 local control zones.
 - 4. 0-10v dimming control output, capable of sinking a minimum of 20 mA of current
 - a. Output shall be programmable to support all standard sequence of operations supported by system.

2.7 WIRED NETWORKED WALL SWITCH SENSORS

- A. Wall switches sensors shall support the following device options:
 - 1. User input control types supported: On / Off or On / Off / Dimming.
 - 2. Occupancy Sensing Technology: PIR or Dual Technology.
 - 3. Daylight Sensing Option: Inhibit Photosensor.

2.8 SYSTEM CONTROLLER

- A. System Controller shall be a multi-tasking, real-time digital control processor consisting of modular hardware with plug-in enclosed processors, communication controllers, and power supplies.
- B. System Controller shall perform the following functions:
 - 1. Facilitation of global network communication between different areas and control zones.
 - 2. Time-Based control of downstream wired and wireless network device.
 - 3. Linking to an Ethernet network.
 - 4. Integration with Building Management System (BMS) and Heating, Ventilation and Air Conditioning (HVAC) equipment.
 - 5. Connection to various software interfaces, including management interface, historical database and analytics interface, visualization interface, and personal control applications.
- C. System Controller shall not require a dedicated PC or a dedicated cloud connection.
- D. Device shall automatically detect all networked devices connected to it, including those connected to wired and wireless communication bridges.
- E. Devices shall have a standard and astronomical internal time clock.
- F. Shall be capable of connecting to the customers Local Area Network (LAN) via IEEE 802.11.x Wireless and IEEE 802.3 wired connection.
- G. System Controllers shall support BACnet IP and BACnet MSTP protocols to directly interface with BMS and HVAC equipment without the need for additional protocol translation gateways.
 - 1. BACnet/MSTP shall support a minimum of 50 additional BACnet MS/TP controllers in addition to the expansion module modules.
 - 2. BACnet/MSTOP shall support 9600 to 115200 baud.
 - 3. System Controller shall be BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building (B-BC) with outlined enhanced features.
 - 4. System controller must support BACnet/IP Broadcast Management Device (BBMS) and Foreign Device Registration (FDR).
- H. Controller shall be equipped for fail safe operation and shall be evaluated for this purpose.
- I. Controller shall be activated by activation of the building fire alarm system.
- J. Controller shall be equipped for activation by the building security system.

2.9 SYSTEM SOFTWARE INTERFACES

- A. Management Interface

1. System shall provide a web-based management interface that provides remote system control, live status monitoring, and configuration capabilities of lighting control settings and schedules.
2. Management interface must be compatible with industry-standard web browser clients.
3. All system software updates must be available for automatic download and installation via the internet.

B. Historical Database and Analytics Interface

1. System shall be capable of providing a browser-based trending and monitoring interface that stores historical data for all occupancy/daylight sensors and lighting loads. Additionally, the system shall optionally upload that data to a cloud based server.

C. Visualization Interfaces

1. System shall be capable of providing an optional web-based visualization interface that displays a graphical floorplan. System data, to include status of occupancy sensors, daylight sensors and light output shall be overlaid to the floorplan to provide a graphical status page.

D. Portable Programming Interface for Standalone Control Zones

1. System shall have option for a portable handheld application interface for standalone control zones.
2. Programming capabilities through the application shall include, but not be limited to, the following:
 - a. Switch/occupancy/photosensor group configuration.
 - b. Manual/automatic on mode.
 - c. Turn-on dim level.
 - d. Occupancy sensor time delays.
 - e. Dual technology occupancy sensors sensitivity.
 - f. Photosensor calibration adjustment and auto-setpoint.
 - g. Trim level settings.

E. Demand Response Client Interface

1. System shall be capable of receiving a signal from the Utility or through a BAS control sequence and initiating load shed in response.
 - a. One full test of the Demand Response plan shall be performed and reports shall be included in the operations and maintenance manual.

PART 3 - EXECUTION

3.1 CONTRACTOR RESPONSIBILITY

- A. Contractor shall provide the proper quantities and types of sensors for complete coverage of the areas to be controlled.

- B. Contractor shall properly install, wire, test and adjust sensors according to manufacturer instructions.
- C. Contractor shall be responsible for a complete operational system as specified.
- D. Contractor shall warrant all equipment and installation for a period of two (2) years from date of substantial completion. Contractor shall make any necessary adjustments to the system at no charge to the Owner during the warranty period.
- E. Contractor/Regional Sales Manager shall provide training to the Owner's representative in the use, operation, adjustment and maintenance of the equipment.
- F. Contractor shall set the sensors time delays per owner's instruction.

3.2 SYSTEM START UP AND COMMISSIONING

- A. To facilitate start-up, all devices daisy-chained together shall automatically be grouped together into a functional lighting control zone.
- B. All lighting control zones shall be able to function according to default settings once adequate power is applied and before any system software is installed.
- C. Once software is installed, system shall be able to auto-discover all system devices without requiring any commissioning.
- D. All system devices shall be capable of being given user-defined names.
- E. All devices within the network shall be able to have their firmware reprogrammed remotely and without being physically uninstalled for purposes of upgrading functionality at a later date.
- F. All sensor devices shall have the ability to detect improper communication wiring and blink it's LED in a specific cadence as to alert installation/startup personnel.

END OF SECTION

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SECTION 26 09 61 – PERFORMANCE LIGHTING 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. This section includes furnishing the following equipment for installation as described under Section 260963:
 - 1. Dimmer Racks
 - 2. Dimmer Modules
 - 3. Intelligent Breaker Panel
 - 4. Panic Control System
 - 5. Emergency Lighting Transfer System
 - 6. Equipment Racks
 - 7. House & Work Lighting Controls
 - 8. Lighting Control Console & Accessories
 - 9. Performance Lighting System Ethernet Network
 - 10. Control Device Faceplates
 - 11. Performance Lighting Outlet Devices
 - 12. Cable Assemblies
 - 13. Spare Parts
- B. Related sections include the following:
 - 1. Performance Lighting System Installation
 - 2. Common Work Results for Electrical
 - 3. Interior Lighting Fixtures
 - 4. Performance Lighting Fixtures
 - 5. Rigging Systems and Controls
 - 6. Commissioning of Electrical Systems

1.3 FULLY WORKING SYSTEMS

- A. Review Drawings and Specifications that affect work in this Section.
- B. Notify Architect upon indication that work in this Section cannot be completed as specified or scheduled.
- C. Provide additional parts or devices required for functional requirements of control systems at no extra cost to Owner.

1.4 DEFINITIONS

- A. Dimmer Rack: Cabinet accommodating dimmer modules, load and line connections, and circuit protection.
- B. Plug-In Module: Modular unit that installs in standardized mounting location within dimmer rack.
- C. Dimmer Module: Plug-in module containing one or more dimmers.
- D. Control Module: Plug-in module containing centralized control electronics for dimmer modules.
- E. Data Communication Protocol: Signal that provides control and feedback communications between devices in control system.
- F. DMX 512: Data communications protocol compliant to USITT DMX-512/1990 specification (ANSI E1.11-2004).
- G. RDM: Data communications protocol compliant to ANSI/PLASA Remote Device Management specification (ANSI/PLASA E1.20 RDM).
- H. ACN: Data communications protocol compliant to ANSI/PLASA Architecture for Control Networks specification (ANSI E1.17-2006 ACN & E1.31 Streaming ACN).
- I. POE / Power Over Ethernet: 802.3AT compliant scheme of powering devices on an Ethernet system.

1.5 QUALITY ASSURANCE AND STANDARDS

- A. References to code, standards, specifications, and recommendations of technical societies, trade organizations, and governmental agencies will refer to the latest edition of such publications adopted and published prior to bid submittal. All codes and standards will be considered a part of this specification as if they were fully included.
- B. Work and materials shall comply with codes and recommendations of:
 - 1. Prevailing national, state and local building codes.
 - 2. UL, ETL, cUL, CSA and CE Labels – where materials and equipment are available under the continuing inspection and labeling service of applicable independent product testing and certification service provide such labels, materials, and equipment.
 - 3. National Fire Protection Associate (NFPA) Publication: National Electrical Code, NFPA70 as applicable to installation and construction of performance lighting and control equipment.
 - 4. NEMA compliance pertaining to components of performance lighting equipment.
 - 5. United States Institute for Theatre Technology, Inc. (USITT) DMX512/1990 (ANSI E1.11-2004).
 - 6. ANSI/PLASA Remote Device Management (ANSI/PLASA E1.20 RDM) and Architecture for Control Networks (ANSI E1.17-2006 ACN & E1.31 Streaming ACN) standards.
 - 7. Institute of Electrical and Electronics Engineers, Inc. (IEEE) 802.3 and 802.11n.

1.6 SUBMITTALS

- A. Bid Submittals
1. Bill of materials: Identify parts by common industry standard numbers and descriptions.
 2. Cut Sheets: Manufacturer's catalog datasheets of all products listed in bill of materials.
 3. Statement: Manufacturer agrees to warranty provisions.
 4. Projected Timetable: List time in weeks for following activities:
 - a. Shop drawing preparation
 - b. Fabrication
 - c. Shipping to site
 - d. System commissioning
 - e. As-built drawing preparation
- B. Shop Drawings
1. Format: Uniform sheet size.
 2. Binding: Bind shop drawings of more than five drawings.
 3. Shop drawings shall include:
 - a. Pictorial drawings: All major components, sub-assemblies, parts list, dimensions, material and finish notes, quality assurance listings.
 - b. Wiring diagrams: Components and interconnections to other components.
 - c. Bill of materials: Accessories and spare parts not drawn.
 - d. Not acceptable: Catalog cut sheets.
 4. Review: Fabrication shall not commence until Theatre Consultant and Architect determine that the shop drawings are in compliance with design intent of Contract Documents.
 5. Revisions: Resubmit as required.
- C. Manuals
1. Format: Letter and/or tabloid size paper.
 2. Binding: Standard 3-ring binder.
 3. Electronic Format: PDF files on USB flash drive.
 4. Manuals shall include:
 - a. System description
 - b. Operation instructions including safety measures.
 - c. Maintenance instructions including recommended procedures and schedules for inspecting system components.
 - d. Catalog cut sheets for all purchased equipment.
 - e. Recommended spare parts list.
- D. As-Built Drawings
1. Format: Letter and/or tabloid size paper.
 2. Binding: Standard 3-ring binder.
 3. Electronic Format: PDF files on USB flash drive.
 4. Delivery: Within one month of system acceptance.

As-built drawings shall include:

 - a. Drawings of all system components.
 - b. Control schematics and risers.
 - c. Bill of materials.

1.7 PROJECT CONDITIONS

- A. Submit: Written confirmation that related electrical work, as shown on Drawings, provides necessary physical accommodations or installation and operation of equipment.
- B. Delivery: Within three weeks of award of contract.

1.8 WARRANTY

- A. Manufacturer shall warrant equipment as follows:
 - 1. According to guarantee provisions in General Conditions.
 - 2. For two years from acceptance of systems, provide services detailed below:
 - a. Technical and Operational Assistance Hotline: Shall be available during normal working hours, evening, and weekends at no additional cost.
 - b. In-stock Spare Parts: Available for major assemblies within 24 hours of receipt.
 - 1) Additional Cost: No charge during duration of warranty for exchanges not caused by misuse.
 - c. Warranty period: Commence upon final acceptance by Owner.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURER

- A. The equipment shall be manufactured by the following:
 - 1. Electronic Theatre Controls
3031 Pleasant View Road
Middleton, WI 53562
608.831.4116
 - 2. Strand Lighting
10911 Petal St
Dallas, TX 75238
214.647.7880
- B. The equipment may be supplied by only one of the following:
 - 1. Barbizon
6437-G General Green Way
Alexandria, VA 22312
703.750.3900
 - 2. Candelabra Controls
15 Canello Place
Mahwah, NJ 07430
201.529.2423
 - 3. Century Lighting Services
18-02 River Rd
Fair Lawn, NJ 07410
201.791.7000
 - 4. M. Cramer & Associates
229 North 12th St
Philadelphia, PA 19107
215.627.1225

5. Parlights
1662 Bowmans Farm Rd
Frederick, MD 21701
301.698.9242
 6. Starlite Productions
9 Whittendale Drive
Moorestown, NJ 08057
856.780.8000
- C. Additional companies wishing to bid shall submit the following 10 days before submission of bids, for review and approval by Theatre Consultant:
1. Firm history.
 2. List of completed installations, comparable in scope to the job described here.
 3. Minimum of 5 representative shop drawing sheets.
 4. If requested, a current certified financial statement showing sufficient financial base for the size of job described here.
- D. Furnishing: Equipment and services shall be provided by one manufacturer.
- E. Experience: Manufacturer shall have been continuously engaged in production of performance lighting and control equipment for at least 20 years.
- F. Emergency Support: Manufacturer shall have a toll-free, 24 hour emergency phone line. Response shall be within 30 minutes of phone call.
- G. Substitutions: Substituted equal products shall not be allowed without prior approval of Architect, Electrical Engineer, Theatre Consultant, or Owner.
- H. New products: Provide latest model of specified products provided latest model retains or exceeds characteristics of products specified herein. Manufacturer shall provide demonstration for Architect, Electrical Engineer, Theatre Consultant, or Owner.
- I. Testing: Test and label all equipment at factory prior to shipment.
- 2.2 PARTS
- A. All materials and equipment provided shall be new and of high quality.
- 2.3 GROUNDING
- A. These systems shall be grounded, as shown on Drawings and in accordance with applicable codes and regulations and/or at the advice of the Manufacturer.
- 2.4 CIRCUIT BREAKERS
- A. Conformity: All applicable codes and standards.
- B. Interrupting capacity: 10,000 amperes SCCR for all primary and secondary circuit breakers unless otherwise specified.

- C. Toggle Guard: Provide for branch circuit breakers in equipment rack component mounting panels, control device faceplates, and outlet device faceplates.

2.5 IDENTIFICATION LABELS

- A. Provide labeling and signage for equipment as described herein and/or noted on the Drawings.
 - 1. Equipment designations and headings: 1/4" height.
 - 2. Secondary information: 3/16" height.

2.6 DIMMER RACKS

- A. Basis of Design: Unison DRd power control system

- B. General

- 1. Dimmer racks shall be dead front switch boards complete with all dimmers, control electronics, timers, circuit breakers, and wiring terminations. No external components shall be required.
- 2. Auxiliary racks shall be available to provide mounting of subcomponents including main circuit breakers, branch circuit breakers and control components.
- 3. Mounting: Floor mount, front access to allow back-to-back or side-by-side installation.
- 4. Electrical operation: 90 to 264 VAC 3 phase, 4 wire + ground, 48 to 63 Hz service.
- 5. Feed Size: Accept up to 400A per phase.
- 6. Power distribution: Copper buss bars. Aluminum buss bars are not acceptable.
- 7. Multiple rack bussing: As required, with optional equipment kit.
- 8. Listing and label: UL/cUL
- 9. Ventilation: forced filtered air using multiple low-noise fans providing redundancy in case of fan failure.
 - a. Configure fans to turn on when control is energized.
 - b. Maintain operating temperature of all components under full load when ambient temperature of dimmer room does not exceed 40°C/104°F.
 - c. Fans shall remain on during thermal shutdown.
- 10. Provide racks configured to receive electrical services shown on electrical Drawings. Provide internal inter-rack bussing as required.
- 11. Provide terminals to accept feed and branch wire sizes shown on Drawings.
- 12. Fault current protection rating: 22,000 SCCR.
- 13. Key module spaces to accept only module amperage specified.
- 14. Module space circuit identification height: 1/4". Verify to match as-built conditions.
- 15. Dimmer bank signage: Permanently attached to equipment with following information:
 - a. Project name
 - b. Manufacturer name, toll-free service phone number, and job reference number
 - c. "Designed by Stages Consultants" statement with phone number and web address
- 16. Dimmer rack section signage: Permanently attached to equipment with following information:
 - a. Performance venue name
 - b. Equipment designation
 - c. Feed size and source identification
 - d. Schedule of dimmer numbers listing use, circuit identification, dimmer type, and load; load information verified to match final as-built conditions

17. Mason Industries ND double deflection neoprene-in-shear type vibration isolation pads shall be provided for each dimmer rack. Neoprene shall be no harder than 50 durometer.

C. Electronics

1. Control electronics shall be microprocessor based, designed specifically for control of dimming systems.
2. Backlit, graphical LCD display shall access following information:
 - a. Rack setup
 - b. Rack status
 - c. Dimmer load
 - d. Temperature monitoring
 - e. Output voltage adjustment per dimmer module
 - f. System configuration
 - g. Operating parameters, presets, levels, fade times
3. Rack shall accept two DMX-512/1990 control signal inputs and one Category 5 or greater IEEE 802.3 Ethernet protocol control signals.
4. Opto-isolated contacted input shall be provided for panic system control.
5. Control modules shall directly support ANSI E1.31 (sACN) and ANSI E1.17 (AECN) network protocols. Control modules that do not support these protocols shall not be accepted.
6. Control signal input of each individual dimmer rack shall be fully opto-isolated from control signal input of any other rack, and fully opto-isolated from any control signal output.

2.7 DIMMER MODULES

A. SCR Dimmer Modules

1. Each module shall contain:
 - a. Circuit breakers
 - 1) Fully magnetic
 - 2) Trip current shall not be affected by ambient temperature
 - 3) Rated for tungsten loads having an inrush of no less than 20 times normal current.
 - 4) Switching duty application rating: 100%
 - 5) Load rating: continuous operation at 100% load
 - b. Solid-state switching module
 - 1) Encapsulated in high impact plastic cases
 - 2) Isolation: 2,500 volts RMS between AC line and control lines
 - c. Toroidal inductors
 - 1) Reduce rate of current rise time.
 - 2) Limit objectionable harmonics
 - 3) Reduce lamp filament "sing"
 - 4) Limit radio frequency interference on line and load conductors.
 - d. Power and control connectors
2. Key modules to prevent interchangeability of modules of differing capacity.
3. Module shall be capable of "hot patching" cold incandescent loads up to full rated capacity without malfunction with control signal at full.
4. Standard Rise Time Dimmers
 - a. Dimmer shall have a rise time of not less than 500 μ s measured at 90 degrees conduction angle from 10% to 90% of output wave form with dimmer operating at

- maximum load. Voltage rate of rise (slew rate) must not exceed 300 mill volts per microsecond in any point of the wave under full load conditions.
5. High Rise Time Dimmers
 - a. Dimmer shall have a rise time of not less than 800 μ s measured at 90 degrees conduction angle from 10% to 90% of output wave form with dimmer operating at maximum load. Voltage rate of rise (slew rate) must not exceed 210 mill volts per microsecond in any point of the wave under full load conditions.
 6. Listing and label: UL/cUL
- B. Non-Dim & Constant Modules
1. Non-dim modules shall utilize a latching type relay and have a full magnetic primary circuit breaker. Modules employing solid state relays shall not be acceptable.
 2. Constant circuit modules shall distribute overcurrent protected power from the dimmer rack to non-dimmed loads. There shall be no moving parts other than the circuit breakers.
 3. Module construction shall be similar in all respects to standard SCR dimmer module above and shall be interchangeable with modules of the same rating.
 4. Listing and label: UL/cUL
- C. Electronic Low Voltage Modules
1. Each dimmer module shall use a solid-state relay (SSR) consisting of two MOSFET semi-conductors, and all required gating circuitry on the high voltage side of an integral, opto-coupled control voltage isolator.
 - a. Dimmers employing triac power devices, pulse transformer, or other isolating devices not providing at least 2,500V RMS isolation shall not be acceptable.
 2. Power efficiency for ELV dimmers shall be at least 99 percent at full load with a no-load loss of 3V RMS.
 3. Dimmer modules shall be available with current ratings of 10 amps (120 volts).
 4. Module construction shall be similar in all respects to standard dimmer modules.
 5. Circuit breakers shall be fully magnetic so the trip current is not affected by ambient temperature. Circuit breakers shall be rated for 100 percent switching duty applications.
 6. Listing and label: UL/cUL
- D. Phase Adaptive Dimmer Module
1. Phase adaptive dimmer modules shall provide forward-phase or reverse-phase angle dimming specifically for LED replacement lamps.
 2. Modules shall provide phase angle and min scale control.
 3. Module shall contain transistor-based power devices, and all required gating circuitry on the high-voltage side of an integral, opto-coupled control voltage isolator.
 - a. Dimmers employing triac power devices, pulse transformers, or other isolating devices not providing at least 3,000V RMS isolation shall not be acceptable.
 4. The dimming engine shall have jitter reduction and dimmer curve smoothing software features.
 5. Module construction shall be similar in all respects to standard dimmer modules.
 6. Circuit breakers shall be fully magnetic so the trip current is not affected by ambient temperature. Circuit breakers shall be rated for 100 percent switching duty applications.
 7. Listing and label: UL/cUL.

2.8 INTELLIGENT BREAKER PANELS

- A. Basis of Design: Sensor IQ relay panel

B. General

1. Relay panel shall be dead front switch boards complete with all relays, control electronics, circuit breakers, and wiring terminations. No external components shall be required.
2. Mounting: Wall mount, surface or recessed.
3. Maximum Dimensions: 64" high x 20" wide x 5.25" deep.
4. Electrical operation: 120/208V 3 phase, 4 wire + ground.
5. Feed Size: Accept up to 400A per phase.
6. Listing and label: UL/cUL; UL508, UL67, UL924
7. Provide terminals to accept feed and branch wire sizes shown on Drawings.
8. Fault current protection rating: 65,000 SCCR.
9. Voltage Separation: Provide between high voltage and low voltage compartments.
10. Branch load circuit breakers shall be provided as required for branch load terminations.
 - a. Listing and label: UL/cUL; UL489
 - b. Integral mechanically held air gap relay
 - c. Trip current shall not be affected by ambient temperature
 - d. Rated for tungsten loads having an inrush of no less than 20 times normal current.
 - e. Switching duty application rating: 100%
 - f. Load rating: continuous operation at 100% load
 - g. Rapid load switching: internal solenoid shall switch load when breaker at "on" position.
11. Branch circuit capacity: 48 poles, 15A to 30A one, two, and three-pole circuits as required.
12. Relay bank signage: Permanently attached to equipment with following information:
 - a. Project name
 - b. Manufacturer name, toll-free service phone number, and job reference number
 - c. "Designed by Stages Consultants" statement with phone number and web address
13. Relay panel section signage: Permanently attached to equipment with following information:
 - a. Performance venue name
 - b. Equipment designation
 - c. Feed size and source identification
 - d. Schedule of relay numbers listing use, circuit identification, relay type, and load; load information verified to match final as-built conditions

C. Electronics

1. Control electronics shall be microprocessor based, designed specifically for control of dimming systems.
2. Backlit, graphical LCD display shall access following information:
 - a. Breaker state
 - b. Relay state
 - c. Current draw
 - d. Voltage
 - e. Energy use over time
3. Rack shall accept DMX-512/1990 control signal input and one Category 5 or greater IEEE 802.3 Ethernet protocol control signals.
4. Opto-isolated contacted input shall be provided for panic system control.
5. Control modules shall directly support ANSI E1.31 sACN network protocol. Control modules that do not support these protocols shall not be accepted.

6. Control signal input of each individual dimmer rack shall be fully opto-isolated from control signal input of any other rack, and fully opto-isolated from any control signal output.

2.9 PANIC CONTROL SYSTEM

- A. The panic control system shall instantly bring a programmable selection of dimmers and non-dim relays to full with the push of "Panic" button. Panic state shall be released with the push of "Normal" button.
- B. The system shall always be enabled at every control location, regardless of the state of other control systems and independent of emergency power transfer relays.
- C. Panic stations shall consist of the following:
 1. Each panic control location shall consist of two EAO series 61 momentary pushbutton switches with requisite switching electronics.
 2. Pushbutton momentary switches shall be illuminated, with colored lens engraved with button label.
 3. One button shall be labeled "Normal" with green lens.
 4. One button shall be labeled "Panic" with red lens and, hinged protective cover.

2.10 EMERGENCY LIGHTING TRANSFER SYSTEM

- A. Basis of Design: ELTS2
- B. General
 1. Emergency lighting transfer system shall be mounted in NEMA 1 type enclosure with hinged locking door.
 2. Enclosure Material: 14 gauge steel.
 3. Mounting: Wall mount, front.
 4. Maximum Dimensions (enclosure containing no more than 12 poles): 36" high x 24" wide x 9" deep.
 5. Maximum Dimensions (enclosure containing no more than 24 poles): 48" high x 30" wide x 9" deep.
 6. Electrical operation: 20/208V 3 phase, 4 wire + ground.
 7. Feed Size: accept up to 150A per phase.
 8. Listing and label: UL/cUL
 9. Provide terminals to accept feed and branch wire sizes shown on Drawings.
 10. Fault current protection rating: 65,000 SCCR.
 11. The emergency transfer system shall monitor three phases of the normal feed. Upon loss of power to one or more phases, normal system failure, or activation of the panic condition designated branch circuits shall be transferred from dimming system to second power source.
 12. Transfer poles: Phase and neutral legs of each branch circuit load.
 13. Transfer Switch Unit: Electrically-operated and mechanically-held.
 14. Electrical operator: Single-solenoid mechanism, momentarily energized.
 15. The switch shall be positively locked and unaffected by voltage variations or momentary outages such that constant contact pressure is maintained and temperature rise at contacts is minimized.

16. The transfer switch shall be rated to withstand the RMS symmetrical short circuit current without welding contacts.
 17. Fire alarm interface: Isolated signal input shall automatically transfer loads to available secondary power source when facility fire alarm is activated.
 18. Test Switch: Key-operated momentary switch for manual control.
- C. Safety Standards: Comply with ANSI/UL1008, ANSI/NFPA 70, ANSI/NFPA 110.
- D. Signage: Permanently attached to equipment with following information:
1. Performance venue name
 2. Equipment designation
 3. Feed size and source identification

2.11 EQUIPMENT RACKS

- A. Basis of Design:
1. Middle Atlantic Products WR series for pull-out frame racks
 2. Middle Atlantic Products DWR series for swing frame racks
- B. General
1. Equipment rack shall be EIA compliant 19", steel cabinet.
 2. Color: Powder coat black
 3. Rackrail Type: 10-32
 4. Maximum Dimensions: 89" high x 24" wide x 33" deep.
 5. Usable Depth: as required for specified equipment
 6. Blank Filler Plates: Provide in un-used spaces. Internal space behind filler plates shall not be obstructed or used.
 7. Panel Legends and Lines: Engrave and filled with engraver's enamel.
 8. Provide non-combustible brackets, shelves, and other supports for heavy components and internal wiring assemblies and harnesses. Provide interior mounting angles to support work-writing tops and drawers.
 9. Component Wiring: 36" long flexible cable harness to numbered barrier terminal block. Terminal block shall be attached to frames in line with associated panels and shall not interfere with adjacent components or filler panels.
 10. Signage: Permanently attached to equipment with following information:
 - a. Project name
 - b. Performance venue name
 - c. Equipment designation
 - d. Feed size and source identification
 - e. Manufacturer name, toll-free service phone number, and job reference number
 - f. "Designed by Stages Consultants" statement with phone number and web address

2.12 HOUSE & WORK LIGHTING CONTROLS

- A. Basis of Design: Unison Paradigm
- B. General
1. Provide microprocessor based, solid state architectural control processor (ACP) that functions independently and in conjunction with lighting control console.

2. ACP shall be capable of controlling dimmer racks, relay panels, LED systems, automated lighting fixtures, and other device via DMX and ACN.
 3. ACP functions:
 - a. Station programming
 - b. Macro sequencing
 - c. Electronic lockout
 - d. Room combine
 - e. Astronomical time clock events
 - f. Preset recall: 512
 - g. Fade time between presets
 - h. Rate of fade time modification
 - i. Concurrent preset recall
 - 1) Multiple presets controlling the same attribute shall first interact based on priority and second based on latest takes precedence (LTP) or highest takes precedence (HTP) as configured.
 - 2) A preset may be designated as an HTP override and shall cause HTP values to be discarded. It shall be possible to specify that a preset or attribute will persist when overridden.
 - 3) When in use, the lighting control console shall override preset levels on a HTP basis. Where there are multiple external sources, then priority and HTP shall be used to perform arbitration.
 - j. Record presets from lighting control console or other control sources on lighting system
 4. Communication protocols:
 - a. DMX-512/1990
 - b. ANSI E1.31 (sACN)
 - c. ANSI E1.17 (ACN)
 - d. EIA-232 serial
 - e. Dry contact closure input and output
 - f. Network Time Protocol
 5. Control channel capacity: 1,024 parameters
- C. Master Stations
1. Master stations shall consist of built-in LED display
 - a. Minimum viewable display size: 7" WVGA
 - b. Minimum resolution: 800x480
 - c. Bezel: Aluminum
 - d. Touch interface: Capacitive with LED backlight
 - e. Viewing angle: 178° horizontal and vertical
 - f. Finish: Shown on drawings
 - g. Provide metal backbox and mounting frames
 2. Connect to control system using category 5e or better wire.
 3. Master stations shall provide control of lighting processor presets, sequences, fade times, macros, timeclock events, and interfaced external systems.
 4. Master stations shall operate using graphic buttons, faders, and other images on programmable control pages. There shall at least 30 custom control pages available.
 5. Graphic controls shall represent the active state of all presets, zones, and devices. Status indication shall be tracked across all stations in real-time, including tracking of fades on graphical fader controls.
 6. Stations shall allow programming of multiple-level passcodes, page lockout, and visibility.

7. Control pages shall include:
 - a. House light presets (House Full, House Half, House Preset, House Out, Cleaning); work light presets (Pre-Show, Show, Post-Show, Rehearsal, Work, Off); system wide presets (Blackout, Night)
 - b. Performance lighting presets with snapshot record function
 - c. House light zone faders and House light master fader
 - d. Work light, run light, and non-dim zone control buttons
 - e. Lockout function to disable other stations and remote switches
 - f. Setup display for administrative functions
8. Page layout and interface functionality shall be determined by the Theatre Consultant following approval of shop drawings. Programming services shall be provided by the Manufacturer.

D. Entry Stations

1. Entry stations shall consist of programmable momentary pushbutton switches.
 - a. Finish: Shown on drawings
 - b. Provide flush or surface backbox
2. Pushbuttons shall provide control of a single channel, lighting process preset, sequence, fade time, macro, timeclock event, and/or interfaced external system as required.
3. Preset Stations shall connect to control system using Manufacturer's recommended wire type, network topology, and communication protocols.

E. Keyswitch Stations

1. Keyswitch stations shall consist of programmable momentary switches.
 - a. Key switch: EAO series 51
 - b. Pushbuttons: Manufacturer's standard
 - c. Finish: Shown on drawings
 - d. Provide flush or surface backbox
2. Keyswitch shall unlock tour and cleaning pushbuttons for a period of one hour.
3. Tour pushbutton shall energize a user programmable preset of house light zones.
4. Cleaning pushbutton shall energize a user programmable preset of house and work light zones.
5. Keyswitch Station shall connect to the control system using Manufacturer's recommended wire type, network topology, and communication protocols.

2.13 LIGHTING CONTROL CONSOLE

A. Basis of Design: ETC Element 2

B. General

1. Lighting control console shall be a microprocessor-based system specifically designed to provide complete control of performance lighting systems.
 - a. External multi-touch screen capability
 - b. Remote video support
 - c. Lighting network device control
 - 1) Direct control of third party sACN/ACN devices
 - 2) DMX512 / RDM hardware interfaces
 - 3) Support MIDI, SMPTE and RS-232 interfaces
2. User interface shall be fully graphical with command line. Control commands shall be accepted as either command line or direct entry.

3. The main control shall consist of numeric keypad, dedicated control keys, context sensitive soft keys, level control wheel, and pointing device.
 4. A blind display mode shall allow viewing and modification of all recordable attributes without affecting live stage levels.
 5. A patch display mode shall be used to display and modify system control channels with their associated data.
 6. Control and programming features for automated fixtures shall include a standard library of fixture profiles; ability to copy and edit existing profiles and create new profiles; and patch displays including channel and output addressing, 16-bit fade resolution, color characterization allowing color mixing and storing in hue and saturation or native device values.
 7. Control channel data shall be recordable as cues, groups, submasters, palettes, effects, macros, curves, and patch contained in non-volatile electronic memory and stored as show data to internal storage or USB storage device.
 8. Simultaneous playback of recorded cue lists shall be possible on up to 200 faders.
 9. The console shall be capable of being placed in Tracking or Cue Only record mode by the user.
 10. Integrated, integral virtual media server shall allow mappable images and animations to rig array. System shall be capable of 40 maps, 12 layers each.
 11. User definable, interactive magic sheet displays shall allow graphical layout of channels, desk functions, and programming tools in live and blind operating modes. Provide standard symbol library and user-import tool for custom graphics.
 12. A freely available offline editing application shall be provided for creation and modification of show data on a personal computer.
 13. A personal computer running client software application shall be able to connect to a control system via the network and view current show data in a mirrored display environment.
 14. The system shall allow remote control from a wireless handheld remote.
 15. The system shall support configuration and operation of two consoles or a console and a dedicated processor as a main and fully tracking backup.
- C. Provide the following control consoles:
1. Venue 1: ETC Element 2 with 144 outputs
- D. Provide with the console (2) external 23" or larger multi-touch monitors, keyboard, mouse, and task lights.
- E. Furnish the following console accessories:
1. Vinyl dust covers for the consoles and monitors. Dust covers shall cover top, sides, front and rear surfaces of equipment.
 2. Cables for control console and remote video interface
 - a. 10'-0" power: 1
 - b. 25'-0" power: 1
 - c. 10'-0" Ethernet: 1
 - d. 25'-0" Ethernet: 1
 3. Surge protected power strips for console and accessories: 1
 4. Portable uninterruptible power supply, APC Smart-UPS 750VA: 1
 5. 8 GB capacity USB storage keys: 1

2.14 PERFORMANCE LIGHTING SYSTEM ETHERNET NETWORK

- A. Provide a fully functioning Ethernet system. Systems using proprietary formats or protocols other than TCP/IP shall not be accepted.
- B. Network Components
1. Provide IEEE 802.3at 10/100/1000 L3 switches in quantities and locations shown in the Drawings and described herein.
 - a. Switches shall contain auto-sensing ports supporting 10Base-T, 100Base-T, and 1000Base-T. Switches shall support IEEE 802.3ab Type 1000Base-T standard.
 - b. Switches shall be rack mounted in standard 19" racks.
 - c. Switches shall have UTP ports on the front face for connection to other network devices via standard 19" patch panels.
 - d. Switches shall have high mean time between failure (MTBF) value as comparatively analyzed with industry standard 802.3at products.
 - e. Provide ports or media converter modules as required for UTP to Fiber-Optic conversion.
 - f. Provide switches in quantities and configurations having sufficient UTP ports for simultaneous connection of all patch bay ports assigned to performance lighting network devices.
 - g. Acceptable manufacturer shall be Cisco Systems or approved equal.
 2. Provide Category 6a or better patch bays as required for termination of network cabling.
 - a. Patch bays shall be rack mounted in standard 19" racks.
 - b. Provide Category 6a or better patch cords as required for connection between the patch bays, switches, and other network devices.
 - c. Provide rack mounted standard 19" cable management systems for each patch panel.
 - d. Acceptable manufacturer shall be Hubbell or approved equal.
 3. Provide Network Services Gateway in quantities and types as shown on Drawings.
 - a. Gateway shall support the following protocols:
 - 1) Dynamic Host Control Protocol (DHCP) for automatic assignment of IP address
 - 2) Dynamic Name Service (DNS)
 - 3) Simple Network Time Protocol (sNTP) for automatic time assignment and synchronization
 - 4) File Transfer Protocol (FTP) for configuration storage and backup
 - 5) Windows File Sharing (SMB) for configuration and file storage and backup
 - b. Gateway shall support real-time logging and notifications of system errors.
 - 1) Logging shall utilize a standard Syslog database.
 - 2) Notifications shall be provided via email messages.
 - c. Gateway shall support storage of performance lighting system and system device configurations.
 4. Provide DMX Gateways in quantities and types as shown on Drawings.
 - a. Gateways shall be intelligent Ethernet devices providing DMX & RDM data distribution over Ethernet data network. Nodes shall be connected using Category 6a or better wire, and powered via Ethernet connection using Power Over Ethernet (IEEE 802.3af). Ethernet connection receptacle shall be Neutrik Ethercon D-Series CAT5e receptacle.
 - b. Gateways shall directly support ANSI E1.31 (sACN) and ANSI E1.17 (ACN) network protocols. Gateways that do not support these protocols shall not be accepted.

- c. There shall be as standard DMX512 5-pin XLR connectors on the front panel, or as shown on the drawings. It shall be possible to factory configure the connectors to be male or female to meet project requirements.
- d. Gateways shall be remotely configured via network system wiring using manufacturer's software, control console interface, or standard Web Browser. Specific DMX channels input or output by Node shall be freely configurable by user. Configuration of Node shall be stored in non-volatile memory.

2.15 PERFORMANCE LIGHTING CONTROL DEVICE FACEPLATES

- A. Faceplate: 1/8" (3mm) aluminum component mounting panel.
- B. Surface back boxes: Supplied by performance lighting manufacturer
- C. Floor boxes: As shown on drawings
- D. Color: Powder coat black, or as shown on drawings
- E. Legends: Engraved in component mounting panel and filled with engraver's enamel of contrasting color. Legends in black panels shall be white.
- F. Components: As shown on drawings
- G. DMX receptacles: Neutrik B-Series XLR receptacles.
- H. Ethernet receptacles: Neutrik Ethercon CAT6a receptacles. Provide Neutrik HX-CAT6A parallel press tool for cable terminations.
- I. Low voltage barrier: Install between control and power receptacles
- J. Mounting hardware: Coordinate device mounting requirements as noted on drawings and per field conditions.

2.16 PERFORMANCE LIGHTING OUTLET DEVICES

- A. Faceplate: 1/8" (3mm) aluminum component mounting panel.
- B. Surface Back boxes: Supplied by performance lighting manufacturer
- C. Floor boxes: As shown on drawings
- D. Components: As shown on drawings
- E. Color: Powder coat black, or as shown on drawings
- F. Legends: Engraved in component mounting panel and filled with engraver's enamel of contrasting color. Legends in black panels shall be white.
- G. Components: As shown on drawings

1. Flush receptacles: Individually mounted, readily replaceable, and installed off-center to allow space for circuit identification labels.
 2. Pigtail receptacles: Suitable strain relief grips for SOOW cables that engages cable's outer jacket.
 3. Pigtail length: 18" (0.5M) or as shown on drawings.
- H. Terminals: Provide numbered screw terminals on barrier terminal blocks for field connections within each device. Devices shall be internally wired by Manufacturer.
- I. Mounting hardware: Coordinate device mounting requirements as noted on drawings and per field conditions.

2.17 SPARE PARTS

- A. Furnish 10% spare parts for all perishable items such as pilot light lamps and fuses.
- B. Furnish 2% spare parts for all low voltage and line voltage connectors, minimum of 2 per type.
- C. Furnish the following additional spare parts:
 1. (2) Spare dimmer and relay modules of each type listed in the Drawings.
 2. (1) Spare dimmer rack control electronics module
 3. (1) Manufacturer's Lighting Control Console spare parts package.

PART 3 – EXECUTION

3.1 SUPERVISION OF INSTALLATION

- A. Manufacturer shall provide instruction and supervision to the Division 26 Contractor as it pertains to the installation of the systems. Provide the necessary personnel for coordination meetings and site visits as requested by the Division 26 Contractor.

3.2 COMMISSIONING

- A. Manufacturer shall provide the services of a qualified on-site engineering representative who shall perform the following:
 1. Supervise and instruct equipment installer in all Manufacturer's requirements and specifications.
 2. Prior to system energization, inspect the finished installation and confirm that the installation conforms to manufacturer's requirements and specifications. Supervise correction of any deficiencies and retest deficient items.
 3. Manufacturer's engineering representative shall be present during energization of the system.
 4. In conjunction with the equipment installer, measure and adjust the full dimmer output voltage at each performance lighting receptacle. Typical voltage shall be uniform at each receptacle regardless of branch wiring length. Specific voltage requirements shall be determined by the Theatre Consultant or Electrical Engineer.
 5. Verify operation of all control devices and network wiring.

6. Configure all hardware and software to a “show ready” state, including:
 - a. Network device addressing
 - b. Ethernet switches configured for industry standard control protocols
 - c. Dimmer and relay patch, dimmer curves, dimmer output voltage, control priority and similar variables
 - d. Panic preset and fade time
 - e. House light control zones, presets, sequences, fade times, macros, timeclock events, and interfaced external systems
 - f. Lighting control console patched 1 to 1 for all control channels in system
 - g. Console accessories such as remote video, tracking backup, and hand-held remote configured to operate with main lighting control console
 - h. DMX node/gateway patch, priority, and soft labeling
 - i. Lighting system computer software
- B. Provide to the Architect and Theatre Consultant a written report confirming that the system has been properly installed and successfully energized within fourteen (14) days of energization

3.3 DEMONSTRATION AND ACCEPTANCE

- A. The Architect and Theatre Consultant (or their representatives) shall witness a full demonstration by the Manufacturer of each feature of each piece of equipment in the system. Comply with the following conditions:
 1. The Manufacturer shall provide all necessary personnel and equipment, including lifts and ladders, to demonstrate fully the system's compliance to the specifications.
 2. Contractor's project representative shall be present during testing as required.
 3. Full and uninterrupted access to all areas shall be provided as necessary for complete testing and demonstration.
 4. All loose equipment provided under this Section shall be on site and available for testing.
 5. All architectural lighting fixtures connected to the dimming system shall be installed and lamped.
- B. Subject to satisfactory on-site demonstration, the Owner's representative shall accept the equipment on behalf of the Owner.
- C. Should the demonstration prove unsatisfactory, the Theatre Consultant and the Architect shall inform the Manufacturer in writing, and the Manufacturer shall rectify the problems. Problems shall be rectified in the shortest time possible. During this period of remedial work, the Owner shall have beneficial use of the equipment. The Warranty period shall commence upon final acceptance by the Owner.

3.4 TRAINING

- A. Provide a factory field service representative to offer instruction to the owner's staff in the proper operation and maintenance of the systems and software for at least 1 full day at a date and time convenient to the Owner.

END OF SECTION

SECTION 26 09 63 – PERFORMANCE LIGHTING SYSTEMS INSTALLATION

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. The work of this Section includes all labor, materials, equipment and services necessary to install the electrical work associated with the Performance Lighting Systems, as described in Section 260961 and shown on the Drawings.
- B. Related sections include the following:
1. Performance Lighting Systems
 2. Common Work Results for Electrical
 3. Architectural Lighting Fixtures
 4. Rigging Systems and Controls

1.3 QUALITY ASSURANCE AND STANDARDS

- A. References to code, standards, specifications and recommendations of technical societies, trade organizations and governmental agencies will refer to the latest edition of such publications adopted and published prior to submittal of the bid. All such codes and standards will be considered a part of this specification as if they were fully included herein.
- B. Work and materials shall comply with the rules and recommendations of:
1. Prevailing national, state and local building codes.
 2. UL, ETL, cUL, CSA and CE Labels – where materials and equipment are available under the continuing inspection and labeling service of applicable independent product testing and certification services provide such labels, materials, and equipment.
 3. National Fire Protection Association (NFPA) Publication: National Electrical Code, NFPA 70 as applicable to installation and construction of performance lighting and control equipment.
 4. NEMA Compliance pertaining to components of performance lighting equipment.
 5. United States Institute for Theatre Technology, Inc. (USITT) DMX512/1990 (ANSI E1.17-2004).
 6. ANSI/PLASA Remote Device Management (ANSI/PLASA E1.20 RDM) and Architecture for Control Networks (ANSI E1.17-2006, E1.31) standards.
 7. Institute of Electrical and Electronics Engineers, Inc. (IEEE) 802.3af and 802.11n.

1.4 CERTIFICATIONS

- A. The Contractor shall submit (as part of the Owner's Manual) certificates from the manufacturer stating that the installed system is operating properly and complies with the manufacturer's recommendations. This information shall be incorporated in the Owner's Manual, as described in 260961
- B. The Contractor shall submit a certificate that the Ethernet system has been tested and complies with all IEEE 802.3, ISO/IEC 8802-3 and PLASA standards. This information shall be incorporated as an appendix to the Owner's Manual, as described in Theatrical Lighting Controls.

1.5 WARRANTY

- A. In addition to the performance lighting controls manufacturer's warranty, provide warranty of the systems and equipment to be free of faulty workmanship or improper adjustment for a period of one year from the date of Owner's acceptance.
- B. Replace items showing evidence of defective materials or workmanship within thirty days after notification. Make repairs without any cost to the Owner.
- C. Resolve any conditions that might present a serious hazard to human life within 24 hours of notification by Owner.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Materials as specified under Division 26.

PART 3 – EXECUTION

3.1 PROTECTION OF EQUIPMENT

- A. Protect the equipment in this and Related Sections from damage and deterioration during all phases of the work, from the time of manufacture to the acceptance of the completed installation.
- B. The Performance Lighting Systems equipment furnished under Section 260961 will become responsibility of the installer until Owner's final acceptance.

3.2 INSTALLATION

- A. Install Performance Lighting Controls system as located on the drawings. Installation shall be in accordance with manufacturer's written instructions, recognized industry practice, and applicable requirements of the National Electrical Code and UL standards.

- B. All load circuit conductors and data wiring for these systems shall be installed in metallic conduit, metal wireways, surface metal raceways, or other approved cable containment. Use of metal-sheathed or armored cable shall not be accepted without prior approval.
- C. Voltage separation shall be maintained between line voltage, low voltage and data wiring.
- D. All load circuit conductors shall be continuous from the dimmer room to the outlet devices or architectural fixture.
- E. All dimmer rack load circuits must have individual neutral conductors. Neutral conductors must be routed directly adjacent to the live conductors of each circuit.
- F. All data wiring shall be continuous from termination point to termination point; no splices or inline connectors shall be allowed.
- G. Field terminations in these systems shall be as follows:
 - 1. Main feed wires shall terminate in pressure lugs on buss bars.
 - 2. Branch load wires shall terminate on screw terminals on barrier terminal blocks, circuit breakers and switches.
 - 3. Control wires shall terminate on screw terminals on barrier terminal blocks and switches, or as noted.
 - 4. Ethernet cables shall be installed and tested in compliance with all IEEE 802.3.ISO/IEC 8802-3 and ETSA standards.
- H. Wire nuts and field soldered connections, except where noted, are not acceptable in these systems.
- I. These systems shall be grounded, as shown on drawings and in accordance with applicable codes and regulations and/or at the advice of the Manufacturer.
- J. Network Cabling
 - 1. Performance Lighting System data cabling shown in Drawings to convey design intent only. Final quantities, types, and topologies shall be per the Manufacturer's approved shop drawings.
 - 2. Provide Fiber Optic Cable as required for all runs greater than 90 meters (300') or as specifically shown in the Drawings.
 - a. Confirm all cable routing distances to determine appropriate use of fiber runs.
 - b. Cable shall be 62.5/125µm fiber optic cable as required to support network components.
 - c. Cable shall exceed the IEEE802.3z Gigabit Ethernet Fiber specification for 62.5/125µm fiber.
 - d. Cable shall exceed the TIA/EIA 568B Fiber specification.
 - 2. Provide UTP Cable as required for all runs under 90 meters (300') unless specifically shown as Fiber Optic Cable in the Drawings.
 - a. Copper cabling and connecting hardware shall fully comply with TIA/EIA 568B standards and with the standard installation of Category 5E products.

3.3 COMMISSIONING

- A. Prior to energization of the system, perform the following tests and inspections following the instructions of the equipment Manufacturer's on-site engineering representative. Correct deficiencies and retest deficient items.
 - 1. Inspect each outlet, faceplate, device and loose equipment for defects, finish failure, corrosion, physical damage, correct labeling, and nameplate.
 - 2. Perform operational tests on mechanical parts and operable devices according to manufacturer's instructions or routine functional operation.
 - 3. Check tightness of electrical connections with torque wrench calibrated within the previous six (6) months using Manufacturer's recommended torque values.
 - 4. Perform continuity testing of each branch load circuit receptacle, determining correct polarity of wiring and correspondence between circuit numbers and labeling. Continuity Test Report shall be available upon request. Any problem(s), i.e. open circuit, short circuit, wrong termination, etc. shall be rectified in a timely manner and re-tested.
 - 5. Test and certify Ethernet network for compliance with all IEEE 802.3, ISO/IEC 8802-3 and ANSI/TIA-568 standards. Network Compliance Test Report shall be available upon request. Any problem(s), i.e. cable length exceeding standards, open circuit, short circuit, wrong termination, etc. shall be rectified in a timely manner and re-tested. Submit final test report data and letter of certification for inclusion as an appendix to the Manufacturer's Instruction and Maintenance Manual.
- B. Energization of the system shall only commence following written approval of the Manufacturer, and shall take place in the presence of the Manufacturer's on-site engineering representative.
- C. In conjunction with the Manufacturer's engineering representative, measure and adjust the full dimmer output voltage at each performance lighting receptacle. Typical voltage shall be uniform at each receptacle regardless of branch wiring length. Specific voltage requirements shall be determined by the Theatre Consultant or Electrical Engineer.

3.4 DEMONSTRATION AND ACCEPTANCE

- A. The Architect and its representative shall witness a full demonstration of each feature of each piece of equipment in the system.
 - 1. Contractor shall provide all necessary personnel and equipment to demonstrate fully the system's compliance to the specifications.
 - 2. Contractor's project representative shall be present during testing as required.
 - 3. Full and uninterrupted access to all areas shall be provided as necessary for complete testing and demonstration.
 - 4. All loose equipment provided under this and Related Sections shall be on site and available for testing.
 - 5. All architectural lighting fixtures circuited to the dimming system shall be installed and lamped.
- B. Subject to the on-site demonstration being satisfactory, the owner's representative shall accept the equipment on behalf of the Owner.
- C. Should the demonstration prove unsatisfactory, the Theatre Consultant and the Architect will inform the Contractor in writing, and the Contractor shall rectify the problems. Problems should be rectified in the shortest time possible. During this period of remedial work, the Owner shall

have beneficial use of the equipment. The Warranty period shall commence upon final acceptance by the Owner.

END OF SECTION

NOT FOR BID

SECTION 26 09 73 – SOUND, VIDEO, & COMMUNICATION SYSTEMS INSTALLATION

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. The work of this Section includes all labor, materials, equipment and services necessary to install the following electrical work associated with the Sound, Video, & Communication Systems, as described in Section 274117 and shown on the Drawings:
1. A complete, pull-ready conduit system for installation of Sound, Video & Communication Systems wiring and devices, including, but not limited to:
 - a. Conduit and raceways.
 - b. Junction/pull boxes.
 - c. Standard back boxes.
 - d. Rack room terminal cabinets and “pull groups” boxes.
 - e. Fittings.
 - f. Drag line (pull line)
 - g. Electrical hardware, etc.
 2. Installation of nonstandard back boxes for Sound, Video & Communication Systems devices provided under Division 27 (to be concurrent with other electrical work).
 3. Electrical power service—including transformers, feeder cable, distribution panels, branch circuit panel-boards, and individual wall receptacles.
 4. Sound, Video & Communication Systems “sound system” isolated ground AC power network.
 - a. Inter-rack AC power wiring shall be the responsibility of Division 27. Single-point termination to the racks shall be conducted on-site by Division 26.
- B. Electrical service for the above work is shown on the E-series drawings
- C. The SVC-series Control Drawings provide block diagrams and equipment locations. The final design of the control systems is the responsibility of the respective Contractors, who will supervise the Electrical Contractor’s work.

END OF SECTION

DIVISION 26 SECTION 26 11 20
UTILITY INCOMING SERVICE PROVISIONS
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SECTION 26 11 20 - UTILITY INCOMING SERVICE PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The general provisions of the Contract, including the General Requirements, apply to the work specified in this Section.
- B. Division 26 Section 260500, *Common Work Results for Electrical* sections apply to work of this section.

1.2 DESCRIPTION OF WORK

- A. The Contractor shall provide all materials and labor required by the utility incoming service provisions.

1.3 RELATED WORK SPECIFIED ELSEWHERE IN DIVISION 26

- A. Section 260500 *Common Work Results for Electrical*.
- B. Section 260573 *Short Circuit Analysis, Coordination Studies and Arc Flash Hazard Analysis*.
- C. Section 260533 *Raceways and Boxes*.
- D. Section 262726 *Wiring Devices*.
- E. Section 260543 *Underground Duct Banks*.
- F. Section 260526 *Grounding and Bonding*.

1.4 UTILITY COMPANY COORDINATION

- A. Contact *Miss Utility* (1-800-257-7777) prior to any excavation or underground work. The Contractor shall verify the location and depth of all utilities. Provide test pits to verify location and depth of all existing utilities crossing new incoming services.
- B. Contact service utility companies immediately upon award of Contract. Do not install related equipment until fully coordinated with appropriate utilities.
- C. Provide all Construction Schedules, dates of requested services, outage windows, equipment locations, etc., necessary for utility work.
- D. The Contractor shall ascertain, from the utility companies, the exact amount of work required in connection of the utilities. Work required which is not provided by the utility companies shall be provided by the Contractor.
- E. Provide and coordinate all temporary services with utility companies.

- F. The Contractor shall coordinate the required separation distances for all utilities.
- G. The Contractor shall obtain all permits and permissions required.

1.5 SUBMITTALS

- A. Certificate of Compliance: Contractor shall submit a documentation certifying that work complies with all utility company requirements including the following:
 - 1. Construction Standards of each Utility Company.
 - 2. Trench and cover Depth.
 - 3. Spacing and Support of Utilities.
 - 4. Installation of underground marking tape.
 - 5. Pull cords and Mandrels.
- B. Photographs: Contractor shall submit photographs of each utility installation at each of the above described levels of completion and attach photographs to Certificate of Compliance for verification. Submit a minimum of six (6) color 4-inch x 6-inch photographs for each utility service.
- C. Submit Certificate of Compliance and photographs to each utility company for verification and approval.
- D. Include Certificate of Compliance, photographs, and utility company approvals in O&M Manual.
- E. The Contractor shall provide and submit all required documentation to each utility company, including service application, site plan and coordination drawings.

1.6 QUALITY ASSURANCE

- A. Comply with the requirements of Delmarva Power Electric Service Manual.
- B. Comply with the requirements of NFPA 70, National Electrical Code.
- C. Comply with the NFPA Standard of Installation.
- D. Comply with NFPA 70E, National Electrical Safety Code.
- E. Contractor shall have experience with not less than 5 comparable projects for which the Contractor completed service provisions with each utility. Contractor shall be familiar with all current utility requirements and guidelines.
- F. Obtain utility company inspector's approval for all work.

PART 2 - PRODUCTS

2.1 ELECTRIC UTILITY COMPANY PROVISIONS

- A. The electric utility company is Delmarva Power.
- B. Coordinate service entrance equipment and layout with power company prior to ordering or installing any service entrance equipment.
- C. Furnish and install all incoming raceway.
- D. Coordinate cable, conduit, lug sizes, etc., for proper interface between utility-owned/installed equipment and Contractor-installed equipment.
- E. Provide grounding and clearances as required by the Utility.
- F. Contact and coordinate service entrance equipment and layout with local power company prior to ordering or installing any service entrance equipment. Contractor shall furnish and install all incoming raceway and service entrance cables. If the power company plans to install cable and/or conduit, the Contractor is responsible for proper coordination of cable, conduit, lug sizes, etc., for proper interface between utility-owned/installed equipment and Contractor-installed equipment.
- G. The Contractor shall ascertain from the utility companies, the available short circuit fault current.
- H. Equipment for Utility Company's Electric Meter.
 - 1. Comply with requirements of Delmarva Power.

2.2 TYPICAL INCOMING SERVICE PROVISIONS

- A. Pull Wire: ¼-inch nylon pull cord with 500 lb. minimum tensile strength in each conduit.
- B. Conduit, Elbows, and Couplings: UL Schedule 40, EB-35, DB-60, DB-120, or ANSI/ASTM F-512 as required by utility for the specific application.
- C. Spacers: Every 4 feet of conduit.
- D. Splice Boxes: Purchase from utility company. Provide as required.
- E. _____ Purchase from utility company. Provide as required.
- F. Underground Marking: Provide detectable warning tape over all conduits. Warning tape shall be as specified in Division 26 Section "Electrical Identification".
- G. Bends: Minimum 5 foot radius (horizontal) and 36-inch radius (vertical), unless otherwise noted.
- H. Concrete for encasement: As specified in Division 26 Section, *Underground Ductbanks*.

- I. Backfill: Virgin soil/select backfill only. Backfill shall be stone dust, rock-free earth, or top soil with no stones larger than 1-1/2-inches in diameter permitted.
- J. Miscellaneous Materials: Provide bushings, bell ends, conduit plugs and other miscellaneous materials as required by utility companies.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Mandrel: Contractor shall pull a mandrel (1/2-inch smaller in diameter than the conduit, and six inches long) through each conduit.
- B. Pull Wires: Pull wires shall be left in all conduits, after mandrel pull.
- C. Coordination: Coordinate location of telephone and CATV wall spaces, race ways, and boxes, as necessary, to interface installation of telephone and CATV systems with other work.
- D. Bushings: Provide conduit bushing at each end of all conduits.
- E. Bell Ends & Plugs: Provide Bell ends and plugs for each conduit.
- F. Sealing Conduits: Provide duct sealant in each conduit after utility cable is installed.

3.2 UTILITY COMPANY ELECTRIC-METERING EQUIPMENT

- A. Install equipment according to utility company's written requirements. Provide grounding and empty conduits as required by utility company. Provide lugs as required by utility.

3.3 PREPARATION

- A. Contractor shall provide conduits at all street or road crossings for all utility facilities.
- B. Provide a level area at final grade for all utility equipment locations.
- C. Coordinate utility line preparation requirements between electric, water, sewer, gas, telephone and CATV.
- D. Provide a clear area for all utility cables of rubble, debris, stumps, and other obstructions.

END OF SECTION

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DIVISION 26 SECTION 26 22 00
TRANSFORMERS
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SECTION 26 22 00 - TRANSFORMERS

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 Section includes dry-type distribution transformers rated 600 V, and less.

1.3 SUBMITTALS

- A. Product Data: Include data on features, components, ratings, dimensions, weight, and performance for each type of transformer specified. Include dimensioned plans, sections, and elevation views. Show minimum clearances and installed devices and features.
- B. Wiring Diagrams: Detail wiring and identify terminals for tap changing and connecting field-installed wiring.
- C. Product Certificates: Signed by manufacturers of transformers certifying that the products furnished comply with requirements.
- D. Qualification Data: For firms and persons specified in *Quality Assurance* Article.
- E. Field Test Reports: Indicate and interpret test results for tests specified in Part 3 of this Section.
- F. Maintenance Data: For transformers to be included in the maintenance manuals specified in Division 01.
- G. Project Record Documents: Record actual transformer locations.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: In addition to requirements specified in Division 01 Section *Quality Control*, an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907; or shall be a full-member company of the International Electrical Testing Association.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3.

- B. Listing and Labeling: Provide transformers specified in this Section that are listed and labeled.
 - 1. The Terms *Listed* and *Labeled*: As defined in NFPA 70, Article 100.
 - 2. Listing and Labeling Agency Qualifications: A *Nationally Recognized Testing Laboratory* as defined in OSHA Regulation 1910.7.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit throughout periods during which equipment is not energized and is not in a space that is continuously under normal control of temperature and humidity.
- B. Store and protect equipment in a dry location with uniform temperature. Cover ventilation openings to keep dust out.

1.6 COORDINATION

- A. 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.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis of Design Manufacturers: Squared Co./Group Schneider NA; Schneider Electric. Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB-GE Electrification Equipment
 - 2. Eaton Corp. Cutler-Hammer Products.
 - 3. Siemens Energy & Automation, Inc.

2.2 TRANSFORMERS, GENERAL REQUIREMENTS

- A. Units: Factory-assembled and tested, air-cooled units of types specified, designed for 60-Hz service.
- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous copper windings without splices, except for taps.

- D. Coil Conductors: Individual insulate secondary conductors and arrange to minimize hysteresis and eddy current losses at harmonic frequencies.
- E. Internal Coil Connections: Brazed or pressure type.
- F. Efficiency: All transformers shall meet or exceed Department of Energy (DOE) 2016 efficiency requirements per 10 C.F.R.&431.196 (2015).
- G. Enclosure: Class complies with NEMA 250 for the environment in which installed. Comply with NEMA ST 20.
- H. Nameplates: Include transformer connection data and overload capacity based on rated allowable temperature rise.
- I. Basic Impulse Level: 10 kV for transformers less than 300 kVA.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Cores: One leg per phase.
- C. Enclosure: Ventilated, NEMA 250, Type 2.
 - 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
- D. Transformer Enclosure Finish: Comply with NEMA 250.
 - 1. Finish Color: Gray.
- E. Taps for Transformers Smaller than 3 kVA: None.
- F. Taps for Transformers 7.5 to 24 kVA: Two 5 percent taps below rated voltage.
- G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.
- H. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- I. K-Factor: Rated Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
 - 1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to K-factor of 13.
 - 2. Indicate value of K-factor on transformer nameplate

- J. Electrostatic Shielding: Each winding shall have an 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 the shield.
 - 3. Shield Effectiveness:
 - a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
 - b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
 - c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.
- K. Wall Brackets: Manufacturer's standard brackets.
- L. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.4 CONTROL AND SIGNAL TRANSFORMERS

- A. Units comply with NEMA ST 1 and are listed and labeled as complying with UL 506.
- B. Ratings: Continuous duty. If rating is not indicated, provide capacity exceeding peak load by 50 percent minimum.
- C. Description: Self-cooled, 2 windings.

2.5 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section 260553, *Electrical Identification*.

2.6 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.91.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Comply with safety requirements of IEEE C2.
- B. Arrange equipment to provide adequate spacing for access and for circulation of cooling air.

- C. Identify transformers and install warning signs according to Division 26 Section 260553, *Electrical Identification*.
- D. 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 and UL 486B.
- E. Install transformers in accordance with NECA SI, and Manufacturer's published instructions, at locations as indicated on the Drawings.
 - 1. Use Manufacturer-approved mounting brackets for transformers supported from building structure.
 - 2. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Division 26 Section 260529, *Hangers and Supports for Electrical Systems*. Refer to detail for pad.
 - 3. Provide working clearances in conformance with NFPA 70.
 - 4. Provide primary and secondary protection using fuses or circuit breakers as indicated on the Drawings.
- F. Set transformers plumb and level.
- G. Use minimum two (2) foot length flexible conduit for connections to transformer case. Make conduit connections to side panel of enclosure.
- H. Mount transformers on vibration isolating pads suitable for isolating transformer noise from building structure.
- I. Provide minimum 4-inch high concrete pad for floor-mounted transformers. Refer to Division 26 Section, "Common Work Results for Electrical" for installation requirements.
- J. Verify mounting supports are properly sized and located, including concealed bracing in walls.

3.2 GROUNDING

- A. Separately Derived Systems. Comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near the transformer. The neutral point of each transformer secondary shall be bonded to the grounding system.
- B. Comply with Division 26 Section 260526, *Grounding and Bonding* for materials and installation requirements.
- C. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: Provide services of an independent electrical testing agency to perform tests on installations made under this section.

- B. Test Objectives: To ensure transformer is operational within industry and manufacturer's tolerances, is installed according to the Contract Documents, and is suitable for energizing.
- C. Test Labeling: On satisfactory completion of tests for each transformer, attach a dated and signed *Satisfactory Test* label to tested component.
- D. Schedule tests and provide notification at least 7 days in advance of test commencement.
- E. Report: Submit a written report of observations and tests. Report defective materials and installation.
- F. Tests: Include the following minimum inspections and tests according to manufacturer's written instructions. Comply with IEEE C57.12.91 for test methods and data correction factors.
 - 1. Inspect accessible components for cleanliness, mechanical and electrical integrity and damage or deterioration. Verify that temporary shipping bracing has been removed. Include internal inspection through access panels and covers.
 - 2. Inspect bolted electrical connections for tightness according to manufacturer's published torque values or, if not available, those specified in UL 486A and UL 486B.
 - 3. Insulation Resistance: Perform megohmmeter tests of primary and secondary winding to winding and winding to ground.
 - a. Minimum Test Voltage: 1000 V, dc.
 - b. Minimum Insulation Resistance: 500 megohms.
 - c. Duration of Each Test: 10 minutes.
 - d. Temperature Correction: Correct results for test temperature deviation from 20 degrees C standard.
- G. Test Failures: Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest. Verify that transformers meet specified requirements.

3.4 CLEANING

- A. On completion of installation, inspect components. Remove paint splatters and other spots, dirt, and debris. Repair scratches and mars on finish to match original finish. Clean components internally using methods and materials recommended by manufacturer. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.5 ADJUSTING

- A. After painting and cleaning, touch up scratches and mars on finish to match original finish.
- B. Adjust transformer taps to provide optimum voltage conditions at utilization equipment throughout normal operating cycle of facility. Record primary and secondary voltages and tap settings and submit with test results.
- C. Adjust buck-boost transformer connections to provide optimum voltage conditions at utilization equipment throughout normal operating cycle of facility.

- D. Occupancy Adjustments: When requested within twelve (12) months of date of Substantial Completion, provide on-site assistance in readjusting transformer tap settings to suit actual occupied conditions. Provide up to two (2) visits to Project site for this purpose without additional cost.
1. Voltage Recordings: Contractor performed. Provide up to 48 hours of recording on the low-voltage system of each medium-voltage transformer.
 2. Point of Measurement: Make voltage recordings at load outlets selected by Owner.

END OF SECTION

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DIVISION 26 SECTION 26 24 13
SWITCHBOARDS
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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.
6. Accessory components and features.
7. Identification.

B. Related Sections include the following:

1. Division 26 Section 260500, *Common Work Results for Electrical* for general and installation materials and methods.
2. Division 26 Section 260553, *Electrical Identification* for identification materials.
3. Division 23 Section 230500, *Instrumentation and Controls of HVAC and Plumbing Systems* for interface between electricity meters and building automation system.

1.3 SUBMITTALS

- A. Product Data: For each product and component specified.
- B. Shop Drawings: For each switchboard, show dimensioned plans and elevations, including required clearances and service space, component and device lists, and a single-line diagram showing main- and branch-bus current ratings and short-time and short-circuit ratings of switchboard. Include the following:

1. Wiring Diagrams: Details of wiring for power and control and differentiating between manufacturer-installed and field-installed wiring.
- C. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- D. Reports of Field Tests and Observations: Certified by testing agency.
- E. Certificates for field testing agency, signed by Contractor, certifying that agency complies with requirements specified in *Quality Assurance* Article below.
- F. Report of Field Tests and Observations: Certified by testing agency.
- G. Maintenance Data: For switchboards to include in the maintenance manuals specified in Division 01.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: In addition to the requirements specified in Division 01 Section 014000, *Quality Control*, an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or shall be a full-member company of the International Electrical Testing Association.
 1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3.
- B. Listing and Labeling: Provide switchboard assemblies specified in this Section that are listed and labeled.
 1. The Terms *Listed* and *Labeled*: As defined in the National Electrical Code, Article 100.
 2. Listing and Labeling Agency Qualifications: A *Nationally Recognized Testing Laboratory* as defined in OSHA Regulation 1910.7.
- C. Comply with NFPA 70.
- D. Comply with NEMA PB 2/PE 2.1/PB2.2.
- E. Comply with UL 891. Equipment shall be UL labeled and service entrance labeled.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in shipping splits of lengths that can be moved past obstructions in delivery path. Additional bus bracing, etc. shall be provided as recommended by manufacturer to allow switchboard to be transported horizontally for low height obstructions in delivery path.
- B. Store so condensation will not occur on or in switchboards. Provide temporary heaters as required to avoid condensation.

- C. Handle switchboards according to NEMA PB 2.1. Use only factory-installed lifting provisions.

1.6 PROJECT CONDITIONS

- 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.
- C. Verify dimensions by field measurements.
- D. Determine suitable path for moving switchboard into place considering Project conditions.
- E. Revise locations and elevations from those indicated as required to suit Project conditions.

1.7 WARRANTY

- A. Manufacturer shall warrant equipment to be free from defects in materials and workmanship for the lesser of one (1) year from date of installation or eighteen (18) months from date of purchase.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following.
 1. ABB-GE Electrification Equipment
 2. Eaton Corp.; Cutler-Hammer.
 3. Siemens Energy & Automation, Inc.

2.2 MANUFACTURED UNITS

- A. Front-Accessible Switchboard: Front and rear aligned, with features as follows:
 1. Main Device: Individually fixed mounted.
 2. Branch Devices: Individually fixed and panel mounted.

- B. Ratings: Provide nominal system voltage, continuous main-bus amperage, and short-circuit current ratings as indicated.
- C. Indoor Enclosures: Steel, NEMA 250, Type 1.
 - 1. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- D. 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.
- E. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks.
- F. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- G. Buses and Connections: Three phase, four wire unless otherwise indicated.
 - 1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated, with tin-plated copper feeder circuit-breaker line connections.
 - 2. Ground Bus: 1/4-by-2-inch- (6-by-50-mm), hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeders and short-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
 - 3. 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.
 - 4. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
- H. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- I. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers for outdoor equipment.

2.3 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 100A through 225 A, field adjustable short time and continuous current settings for circuit-breaker frame sizes 250A through 400A.
2. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings for circuit breaker frame sizes 600A and larger:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 3. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Compression style, suitable for number, size, trip rating and conductor material.
 - c. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip 55 percent of rated voltage.
- B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current. Provide for main circuit breaker(s).
1. Fixed circuit-breaker mounting.
 2. Two-step, stored-energy closing.
 3. Full-function, microprocessor-based trip unit with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time time adjustments.
 - c. Ground-fault pickup level, time delay, and I^2t response.
 4. Data Acquisition System for each main breaker.
 5. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 6. Control Voltage: 120-V ac.
- C. Fuses are specified in Division 26 Section 262813, *Fuses*.
- D. Provide an energy-reducing maintenance switch with local status indicator for all circuit breakers rated or can be adjusted to 1200A or higher.
- 2.4 CONTROL POWER
- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

2.5 ELECTRONIC METER WITH DIGITAL DISPLAY

- A. Three-phase electronic type suitable for connection to three (3) and four (4) wire circuits with the following features:
1. Meter shall be capable of measuring amperes (A), volts (V), power factor (PF), kilowatts (kW), kilowatt demand (kWd), kilovolt-amperes (KVA), kilovolt-amperes demand (kVAd), kilowatt-hours (kWh), kilovolt-ampere hours (kVAh), and Total Harmonic Distortion (THD).
 2. Meter shall be equipped with a minimum of one (1) RS-485 Modbus communication port, one (1) digital input, one (1) KY-type digital output, and one (1) analog output.
 3. Meter shall provide a 0-10VDC, 4-20mA, or a dry contact pulse output signal for interfacing with the building management (automatic temperature control) system provided under Division 23.
 4. Meter shall be equipped with high-visibility, anti-glare, backlit LCD display offering multi-phase measurements, summary services, bar charts, intuitive navigation, and selectable languages.
 5. Measurements shall meet the accuracy requirements of IEC 62053-22 Class 0.5S and ANSI C12.20 Class 0.5S.
 6. Meter shall be equipped with non-volatile on-board memory for capable of extensive logging of min/max values, energy and demand, maintenance data, alarms and any measured parameters.
 7. Meter shall provide custom alarming with time stamping.
 8. Current transformers shall be Square D Type 100R or approved equal.
 9. Potential transformers shall be provided where 277/480V metering is required, unless electronic meter is DIN rail compatible and is mounted directly to the switchboard bussing.
- B. Electronic meters shall be Square D Company, PowerLogic PM 8000 Series, or approved equal by acceptable manufacturer.

2.6 METERING TRANSFORMERS

- A. Manufacturer: Shall be Square D Company.
- B. Current Transformers: ANSI C57.13.5 ampere secondary.
- C. Voltage Transformers: ANSI C57.13;120 V single secondary, (Not required for type PM meters).

2.7 SURGE PROTECTIVE DEVICES

- A. Description: Surge Protective Devices (SPDs) installed in switchboards.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Square D Company - "IMA" Series (Basis of Design)
 - 2. ABB-GE Electrification Equipment
 - 3. Eaton Corporation; Cutler-Hammer Products
 - 4. Siemens Energy & Automation, Inc.
- C. The manufacturer of the SPD shall be the same as the manufacturer of the electrical distribution equipment in which the SPDs are installed and shipped.
- D. Standards - Most recent editions of:
 - 1. Underwriters Laboratories:
 - a. ANSI/UL 1449 - "Surge Protective Devices"
 - b. UL 1283 - "Electromagnetic Interference Filters"
 - 2. ANSI/IEEE C62.41.1-2002, C62.41.2-2002, C62.45-2002
 - 3. National Electrical Code: Article 285 - "Surge Protective Devices, 1 kV or Less"
- E. Listing Requirements:
 - 1. SPD shall bear the UL Mark and shall be Listed to most recent editions of UL 1449 and UL 1283. "Manufactured in accordance with" is not equivalent to UL Listing and does not meet the intent of this Specification.
- F. SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR). Fuse ratings shall not be considered in lieu of demonstrated withstand testing of SPD, per NEC Article 285.6
- G. SPD shall be UL labeled as Type 1, intended for use without need for external or supplemental overcurrent controls. Every suppression component of every mode, including Neutral-Ground (N-G), shall be protected by internal overcurrent and thermal overtemperature controls.
- H. SPD shall be UL labeled with 20kA I-nominal (I-n) for compliance to UL 96A - "Installation Requirements for Lightning Protection Systems" for Master Label Certificate, and NFPA 780 - "Standard for the Installation of Lightning Protection Systems."
- I. Minimum surge current capability (single pulse rated) per phase shall be as follows:
 - 1. Service-Entrance Equipment: 320kA
 - 2. Other than service entrance equipment: 250kA

J. SPD shall provide surge current paths for all modes of protection: Line-Neutral (L-N), Line-Ground (L-G), and Neutral-Ground (N-G) for Wye systems; Line-Line (L-L), and Line-Ground (L-G) in Delta and impedance grounded Wye systems.

K. UL 1449 Listed Voltage Protection Ratings (VPRs) shall not exceed the following:

<u>System Voltage</u>	<u>L-N</u>	<u>L-G</u>	<u>L-L</u>	<u>N-G</u>
480Y/277V	1200V	1200V	1800V	1200V
208Y/120V	700V	1200V	700V	700V

L. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) L-N shall not be less than the following:

<u>System Voltage</u>	<u>MCOV</u>	<u>Allowable System Voltage Fluctuation (%)</u>
480Y/277V	320V	15%
208Y/120V	150V	25%

M. SPD shall be constructed of one self-contained suppression module per phase.

N. Visible indication of proper SPD connection and operation shall be provided. SPD shall include LED indicator lights which shall indicate which phase as well as which module is fully operable. The status of each SPD module shall be monitored on the front cover of the enclosure as well as on the module.

O. A push-to-test button shall be provided to test each phase indicator. Push-to-test button shall activate a state change of dry contacts for testing purposes.

P. SPD shall be equipped with an audible alarm which shall activate when any one of the surge current modules has reached an end-of-life condition. An alarm on/off switch shall be provided to silence the alarm. The switches and alarm shall be located on the front cover of the enclosure.

Q. A connector shall be provided along with dry contacts (normally open or normally closed) to allow connection to a remote monitor or other system. The output of the dry contacts shall indicate an end-of-life condition for the complete SPD or module.

R. Terminals shall be provided for necessary power and ground connections.

S. A transient voltage surge counter shall be located on the diagnostic panel on the front cover of the enclosure. The counter shall be equipped with a manual reset and battery backup to retain memory loss upon loss of AC power.

T. SPD shall have a warranty period of ten (10) years from date of invoice. Warranty shall be the responsibility of the electrical distribution equipment manufacturer and shall be supported by their respective field service division.

2.8 IDENTIFICATION

- A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.
- B. Nameplates and label products are specified in Division 26 Section 260553, *Electrical Identification*. Compartment Nameplates: Engraved laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws.
- C. Nameplates: Engraved nameplates with 1/4" high white lettering shall be furnished for all mains and feeder circuits including control fuses and also for all indicating lights and instruments. Nameplates shall give item designation and circuit number as well as frame size and appropriate trip rating. Furnish Master Nameplate giving switchboard designation, voltage ampere rating, short circuit rating, manufacturer's name, general order number and item number.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive switchboard for compliance with installation tolerances and other conditions affecting performance of switchboards.
 - 1. Do not proceed with installation until unsatisfactory conditions have been corrected.
 - 2. Verify dimensions of switchboard and working space clearances.
- B. Verify that all neutral conductors are bonded to the system ground at the service-entrance prior to installation of the surge protective device.
- C. Verify that neutral-ground bonds do not exist at locations that are not service entrances or separately derived power sources.

3.2 INSTALLATION

- A. Install switchboards level and plumb as indicated, according to manufacturer's written instructions and NEM, PB 2.1.
- B. Equipment mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section 033000, *Cast-in-place concrete*.
 - 1. 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.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 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 switchboards.

- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D. Operating Instructions: Frame and mount 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 the front of switchboards.
- E. Install filler plates in unused spaces of panel-mounted sections.
- F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
 - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- G. Do not energize or connect service-entrance equipment and switchboards to their sources until surge protective devices are properly installed and connected.
- H. Comply with NECA 1.

3.3 CONNECTIONS

- A. Connect switchboards and components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten electrical connectors and terminals, including screws and bolts, according to manufacturer's published torque tightening values. Use a calibrated torque wrench. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Neutral and ground conductors shall be isolated and terminated only at their respective bus bars. There shall only be one neutral-ground connection in service-entrance equipment by means of a removable main bonding jumper. Neutral and ground terminations at one bus bar shall not be acceptable.
- C. Coordinate interface between digital electricity meter and building ATC system with Division 23 Contractor. Provide factory assistance with mapping out any data points with Division 23 Contractor.

3.4 IDENTIFICATION

- A. Identify field installed wiring and components and provide warning signs as specified in Division 26 Section 260553, *Electrical Identification*.
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section 260553, *Electrical Identification*. 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 Division 26 Section 260553, *Electrical Identification*.

- C. Contractor shall provide a framed record drawing indicating final arrangement and modifications and capacities of switchboard and electrical system one-line for easy reference. Mount on switchboard room wall. Contractor shall provide record drawing.

3.5 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Make insulation-resistance tests of each switchboard bus, component, and connecting supply, feeder, and control circuits.
 - 2. Make continuity tests of each circuit.
- B. Testing Agency: Provide the services of a qualified independent testing agency to perform specified acceptance testing.
- C. Acceptance Testing: After installing switchboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements:
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.12 as appropriate. Certify compliance with test parameters and submit all test results for review and approval. Include test results in O&M Manual.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.
 - 3. Measure resistance of switchboard insulation.
 - 4. Provide ground fault testing in accordance with NETA ATS.
 - 5. Provide phase loss/failure testing in accordance with manufacturer's instructions/requirements to verify that phase loss relay at main circuit breaker is fully operational.

3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust stable circuit-breaker trip ranges as specified in Division 26 Section 260573, *Short Circuit Analysis, Coordination Study, and Arc Flash Hazard Analysis*.

3.7 CLEANING

- A. Upon completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.8 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.9 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.

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DIVISION 26 SECTION 26 24 16
PANELBOARDS
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SECTION 26 24 16 - PANELBOARDS

PART 1 - GENERAL

1.1. RELATED DOCUMENTS

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

1.2. SUMMARY

- A. This Section includes distribution panelboards, lighting and power panelboards with associated auxiliary equipment rated 600 V and less.
- B. Related Sections include the following:
 - 1. Division 26 Section 260500, *Common Work Results for Electrical* for general materials and installation methods.
 - 2. Division 26 Section 260553, *Electrical Identification* for labeling materials.
 - 3. Division 26 Section 264313, *Surge Protective Devices*.

1.3. SUBMITTALS

- A. Product Data: For each type of panelboard, accessory item, and component specified.
- B. Shop Drawings: For panelboards. Include dimensioned plans, sections, and elevations. Show tabulations of installed devices, major features, and voltage rating. Include the following:
 - 1. Enclosure type with details for types other than NEMA 250, Type 1.
 - 2. Bus configuration and current ratings.
 - 3. Short-circuit current rating of panelboard.
 - 4. Feature characteristics, ratings, and factory settings of individual protective devices and auxiliary components.
 - 5. Wiring Diagrams: Details of schematic diagram including control wiring and differentiating between manufacturer-installed and field-installed wiring.
- C. Qualification Data: For firms and persons specified in *Quality Assurance* Article.
- D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

- E. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.
- F. Maintenance Data: For panelboard components to include in the Operation and Maintenance Manuals specified in Division 01.
- G. Project Record Data: Record actual locations of products, indicated actual branch circuit arrangement.

1.4. QUALITY ASSURANCE

- A. Testing Agency Qualifications: In addition to the requirements specified in Division 01 Section 014000, *Quality Control* an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or shall be a full member company of the International Electrical Testing Association.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3 of this Section.
- B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 - 1. The Terms *Listed* and *Labeled*: As defined in the National Electrical Code, Article 100.
 - 2. Listing and Labeling Agency Qualifications: A *Nationally Recognized Testing Laboratory* as defined in OSHA Regulation 1910.11.
- C. Comply with NFPA 70, *National Electrical Code*.
- D. Comply with NEMA AB1, *Molded Case Circuit Breakers*.
- E. Comply with NEMA PB1, *Panelboards*.
- F. Comply with NEMA PB1.1, *Instructions for Safe Installation, Operation & Maintenance of Panelboards Rated 600 Volts or Less*.

1.5. EXTRA MATERIALS

- A. Furnish extra material that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Provide 2 spares of each type for panelboard cabinet lock.
 - 2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (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.

1.6. 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 NEMA PB 1.

1.7. PROJECT CONDITIONS

A. Environmental Limitations:

- 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards 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 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 1, usual service conditions as follows:

- 1. Ambient temperatures within limits specified.
- 2. Altitude not exceeding 6600 feet (2000 m).

1.8. COORDINATION

- 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.

PART 2 - PRODUCTS

2.1. GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Enclosures: flush- and surface-mounted cabinets. Piano hinged doors and covers.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 4.
 - c. Kitchen Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
 - d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2. Hinged Front Cover: Entire front trim piano hinged to box and with piano hinged door within hinged trim cover.
 3. Finishes:
 - a. Panels and Trim: 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.
 4. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
 5. Multiple-Section Panelboards shall consist of two or more cabinets with identical interiors mounted under separate trims. Cabinets, trim, and doors shall be of the same size. Main lugs and busses of each section shall be rated as indicated on the Drawings. Where main breakers are indicated in multi-section panelboards, the main breaker shall be contained in one section with through-feed lugs and sub-feed cables installed within panel, equal to the incoming feeder size. All busses and lugs shall have ampere capacity equal to or greater than the main breaker ampere rating. Loads shall be divided as evenly as practical between the sections, in addition to being balanced over the phases.
- B. Incoming Mains Location: Top and bottom.
- C. Phase, Neutral, and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
- D. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Main and Neutral Lugs: Compression type.
 3. Ground Lugs and Bus Configured Terminators: Compression type.
 4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 6. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- E. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
- F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

- G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2. DISTRIBUTION PANELBOARDS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:
 - 1. ABB-GE Electrification Equipment
 - 2. Eaton Corp.; Cutler-Hammer.
 - 3. Siemens Energy & Automation, Inc.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.
- C. Doors: Piano hinged doors and covers. Secured with vault-type latch with tumbler lock; keyed alike.
 - 1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.
- D. Mains: Circuit breaker or Lugs only, as indicated.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

2.3. LIGHTING AND APPLIANCE PANELBOARDS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:
 - 1. ABB-GE Electrification Equipment
 - 2. Eaton Corp.; Cutler-Hammer.
 - 3. Siemens Energy & Automation, Inc.
- B. Panelboards: NEMA PB lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker or lugs only, as indicated.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Piano hinged doors and covers. Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- F. Column Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.4. DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:
1. ABB-GE Electrification Equipment
 2. Eaton Corp.; Cutler-Hammer.
 3. Siemens Energy & Automation, Inc.
- B. 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 level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 100A through 225A, field adjustable short-time and continuous current setting for frame sizes 250A and larger.
 - a. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - b. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - c. Ground-Fault Equipment Protection (GFEPP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - d. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
 - e. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - 1). Standard frame sizes, trip ratings, and number of poles.
 - 2). Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 - 3). Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - 4). Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 50 percent of rated voltage.
 - 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 circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
 - 7). Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
 - 8). Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
 - 9). Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.5. ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation per manufacturer's recommendations.
- B. Portable Test Set: Provide for testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1. INSTALLATION

- A. Install panelboards and accessory items according to NEMA PB 1.1.
- B. Mounting: Plumb and rigid without distortion of box. Mount flush panelboards uniformly flush with wall finish.
- C. Install filler plates in unused spaces.
- D. Wiring in Panelboard Gutters: Arrange conductors into groups, and bundle and wrap with wire ties after completing load balancing.
- E. Two or three pole circuit breakers shall be common trip type. Single pole breakers with handle ties will not be permitted.
- F. Tandem circuit breakers will not be permitted.
- G. Multiple-section panelboards, as required by number of branch circuit breakers, shall consist of two or more cabinets with identical interiors mounted under separate trims. Cabinets, trims, and doors shall be the same size. Main lugs and busses of each section shall be rated as indicated on the Drawings. Where main breakers are indicated in multi-section panelboards the main breaker shall be contained in one section with feed-through lugs and sub-feed cables installed within panel, equal to the incoming feeder size. All buses and lugs shall have ampere capacity equal to or greater than the main breaker ampere rating. Loads shall be divided as evenly as practical between the sections in addition to being balanced over the phases.
- H. Provide ground buses on panelboards as indicated on the Drawings. Ground bus shall be similar in all respects to neutral bus.
- I. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289, *Application Guide for Ground Fault Circuit Interrupters*.
- J. Branch circuit breakers (or switches) serving clocks, telephone and communications equipment, refrigerators, exit signs, fire alarm system controls, etc., shall be equipped with lock clips to prevent accidental operation.

- K. Branch circuit breakers serving electric water coolers shall be GFCI type for personnel protection (5mA).
- L. Branch circuit breakers serving vending machines shall be GFCI type for personnel protection (5mA).
- M. Branch circuit breakers serving receptacles and appliances located under kitchen ventilation hoods shall be equipped with shunt-trip mechanisms.
- N. Height: Six-feet, six-inches to top of panelboard; install panelboards taller than 6 feet with bottom no more than 4 inches above the floor. Top breaker maximum height not to exceed 6 feet 8 inches.
- O. Do not energize or connect service-entrance equipment and panelboards to their source until surge protective devices are properly installed and connected.

3.2. IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section 260553, *Electrical Identification*.
- B. Panelboard Nameplates: Label each panelboard with engraved laminated-plastic or metal nameplates mounted with corrosion-resistant screws.
- C. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section 260553, *Electrical Identification*.
- D. Panelboard Circuit Directories: Provide a typewritten directory, indicating plainly what each branch circuit of the panelboard serves and where. Provide additional information as required by NEC. Spaces and spare breakers shall be written in pencil. Copying of Contract Drawing Panel Schedules and Descriptions shall not be acceptable. Circuit directory shall reflect final circuit connections, loads and locations after balancing of panelboard loads.

3.3. GROUNDING

- A. Make equipment grounding connections for panelboards as indicated.
- B. Provide ground continuity to main electrical ground bus as indicated.

3.4. CONNECTIONS

- A. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

- B. Neutral and ground conductors shall be isolated and terminated only at their respective bus bars. There shall only be one neutral-ground connection in service-entrance equipment by means of a removable main bonding jumper. Neutral and ground terminations at one bus bar shall not be acceptable.

3.5. FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:

- 1. Make insulation-resistance tests of each panelboard bus, component, and connecting supply, feeder, and control circuits.
- 2. Make continuity tests of each circuit.
- 3. Provide set of Contract Documents to test organization. Include full updating of final system configuration and parameters where they supplement or differ from those indicated in the original Contract Documents.

- B. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing.

- C. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

- 1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
- 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units, and retest.
- 3. Reports by Testing Organization: Report written reports of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made.
- 4. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating results of tests and inspections, responsible organization and person, and date.
- 5. Protective Device Ratings and Settings: Verify indicated ratings and settings to be appropriate for final system configuration and parameters. Where discrepancies are found, recommend final protective device ratings and settings. Use accepted ratings or settings to make the final system adjustments.

- D. Visual and Mechanical Inspection: Include the following inspections and related work:

- 1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
- 2. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
- 3. Check panelboard mounting, area clearances, and alignment and fit of components.
- 4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
- 5. Perform visual and mechanical inspection and related work for over-current protective devices.

6. Verify that all neutral conductors are bonded to the system ground at the service-entrance prior to installation of the surge protective device.
 7. Verify that neutral-ground bonds do not exist at locations that are not service entrances or separately derived power sources.
- E. Electrical Tests: Include the following items performed in accordance with manufacturer's instructions:
1. Insulation resistance test of buses and portions of control wiring that is disconnected from solid-state devices. Insulation resistance less than 100 megohms is not acceptable.
 2. Ground resistance test on system and equipment ground connections.
 3. Test main and subfeed over-current protective devices.
 4. Test phase loss relay(s) at panelboards to verify that phase loss relays are fully operational.
- F. Retest: Correct deficiencies identified by tests and observations and provide retesting of panelboards by testing organization. Verify by the system tests that the total assembly meets specified requirements.
- 3.6. ADJUSTING
- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
 - B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section 260573, *Short Circuit Analysis, Coordination Study and Arc Flash Hazard Analysis*.
 - C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 1. Measure as directed during period of normal system loading.
 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.
- 3.7. PROTECTION
- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.8. CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

END OF SECTION

NOT FOR BID

DIVISION 26 SECTION 26 24 17
ELECTRONICALLY OPERATED CIRCUIT-BREAKER PANELBOARDS
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SECTION 26 24 17 ELECTRONICALLY OPERATED CIRCUIT-BREAKER 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: Panelboards using electronically controlled, electrically operated circuit breakers.

1.3 DEFINITIONS

- A. DDC: Direct digital control.
- B. IP: Internet protocol.
- C. 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.
- D. 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.
- E. RS-485: A serial network protocol similar to RS-232, complying with TIA-485-A.

1.4 SUBMITTALS

- A. Product Data: For each type of panelboard, accessory item, and component specified.
- B. Shop Drawings: For each electronically operated, circuit-breaker panelboard and related equipment:
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Show enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 6. Include diagrams for power, signal, and control wiring.
 - 7. 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.

- C. Qualification Data: For Firm and person specified in Quality Assurance Article.
- D. Field quality-control reports.
- E. Panelboard Schedules: For installation in panelboards, submit final versions after load balancing.
- F. Operation and Maintenance Data: For electronic controls to include in emergency, operation, and maintenance manuals.
- G. Project Record Data: Record actual location of products, indicated actual branch circuits arrangement.:

1.5 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Electrically Operated, Molded-Case Circuit Breakers: Equal to 10 percent of amount installed, but no fewer than 4.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: In addition to the requirements specified in Division 01 Section 014000, *Quality Control* an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories (Title 29, Part 1907), or shall be a full member company of the International Electrical Testing Association.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3 of this Section.
- B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 - 1. The Terms *Listed* and *Labeled*: As defined in the National Electrical Code, Article 100.
 - 2. Listing and Labeling Agency Qualifications: A *Nationally Recognized Testing Laboratory* as defined in OSHA Regulation 1910.7.
- C. Comply with NFPA 70, *National Electrical Code*.
- D. Comply with NEMA AB1, *Molded Case Circuit Breakers*.
- E. Comply with NEMA PB1, *Panelboards*.
- F. Comply with NEMA PB1.1, *Instructions for Safe Installation, Operation & Maintenance of Panelboards Rated 600 Volts or Less*.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Handle and prepare panelboards for installation according to NEMA PB 1.1.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

1.9 PROJECT CONDITIONS

- A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weather-tight. All work in spaces is complete and dry, work above panelboards 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 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified
2. Altitude not exceeding 6600 feet (2000 m).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:
1. ABB/GE Electrification Equipment
 2. Eaton Corp.; Cutler-Hammer.
 3. Siemens Energy & Automation, Inc.
- B. Source Limitations: Obtain electrically operated circuit breakers and power distribution components from single manufacturer.

2.2 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Enclosures: Flush- and surface-mounted cabinets. Piano hinged doors and covers.
1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 4.
 2. Hinged Front Cover: Entire front trim piano hinged to box and with piano hinged door within hinged trim cover.
 3. Finishes:
 - a. Panels and Trim: 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.
 4. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
- B. Incoming Mains Location: Top and bottom.
- C. Phase, Neutral, and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 3. Extra-Capacity Neutral Bus: Neutral bus rated 100 percent of phase bus and UL listed as suitable for nonlinear loads.
- D. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Main and Neutral Lugs: Compression type.
 3. Ground Lugs and Bus-Configured Terminators: Compression type.
 4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 6. Extra Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- E. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- F. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

- G. Input signal from field-mounted or on-board signal source shall open or close one or more electrically operated circuit breakers in the electronically operated, circuit-breaker panelboards. Any combination of inputs shall be programmable to any combination outputs.
- H. 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.
- I. Comply with 47 CFR, Subpart A and Subpart B, for Class A digital devices.

2.3 PERFORMANCE REQUIREMENTS

- A. Expansion Requirements: Capacity for future expansion of number of control functions by 25 percent of current capacity; to include equipment ratings, housing capacities, spare spaces for circuit breakers, terminals, number of conductors in control cables, and control software.
- B. Interface with DDC System for HVAC: Provide hardware and software to enable the DDC system for HVAC to monitor, control, display, and record data for use in processing reports.
 - 1. Hardwired Points:
 - a. Monitoring: On-off status.
 - b. Control: On-off operation.
 - 2. Communication Interface: Comply with ASHRAE 135 communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor electronically operated circuit breakers from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at panelboard controller shall be available through the DDC system for HVAC.

2.4 PANELBOARDS

- A. Electronically operated, circuit-breaker panelboards may contain remotely operated circuit breakers and standard branch circuit breakers specified in Section 262416 "Panelboards."
- B. Assemblies: Comply with UL 67 and NEMA PB 1.
- C. Surge Protective Device: Field mounted, complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

2.5 CIRCUIT BREAKERS

- A. Remotely operated branch circuit breakers shall provide branch circuit overcurrent protection.
- B. Labeled with SWD and HID Ratings: Comply with UL 489 for 15- and 20-A, single-pole branch devices. 15- and 20-A circuit breakers, if scheduled, shall be a product of same manufacturer, and be of same class as the rated circuit breakers.
- C. Switching Endurance Rating: Not less than 50,000 full-load open/close/open remote operations.

- D. Remotely Operated Circuit Breakers: Manual override switch or handle position shall enable or disable the remote operation of the device and allow breaker handle to manually control the breaker's on-off status.

2.6 MAIN CONTROLLERS

- A. Description: Controllers shall contain the power supply and electronic control for operating and monitoring remotely operated branch circuit breakers.
 - 1. Comply with UL 916 (CSA C22.2, No. 205); with a microprocessor-based, solid-state, 365-day timing and control unit.
 - 2. Power Supply: Powered from the panelboard, sized to provide control power for the operation of the remotely operated circuit breakers, controller, bus system, low voltage inputs, and field-installed sensors.
 - 3. Integral keypad and digital-display front panel for local setup, including the following:
 - a. Log and display remotely operated breaker on-time.
 - b. Provision to accept downloadable firmware so that the latest features may be added in the future without replacing the module.
 - 4. Nonvolatile memory shall retain all setup configurations. After a power failure, the controller shall automatically reboot and return to normal system operation.
 - 5. Ethernet Communications: Comply with ASHRAE 35 protocols.
 - a. Each input connected to the controller shall control any remotely operated breaker in any other networked electronically operated, circuit-breaker panelboard.
 - b. A schedule programmed at one controller shall be able to control any remotely operated breaker in any other networked panelboard.
 - 6. Time Synchronization: The timing unit shall be updated not less than every 24 hours with the network time server.
 - 7. Web Server: Display information listed below over a standard Web-enabled server for displaying information over a standard Web browser.
 - a. A secure, password-protected login screen for modifying operational parameters, accessible to authorized users via Web page interface.
 - b. Separate Web page, showing status of each main and slave electronically operated, circuit-breaker panelboards with the arrangement of breakers on the page matching the physical appearance of the panel. Status shall include breaker nametags, pole configuration, location in panel, actual contact state (on-off/tripped/manual), and breaker on-time.
 - c. Panel summary showing the master and slave panels connected to the controller.
 - d. Controller diagnostic information.
 - e. Show front panel mimic screens for setting up controller parameters, input types, zones, and operating schedules. These mimic screens shall also allow direct breaker control and zone overrides.
 - 8. Alarm and E-mail Notification: Automatically initiate alarms based on preconfigured conditions listed below and routing alarm alerts as set at the control panel.

- a. General Alarms: Power loss, non-responding breakers, loss and restoration of sub-net communications, loss and restoration of serial port communications, loss and restoration of DDC system for HVAC commands.
- b. Specific Alarms: Input status, zone status, breaker status on-time (0 to 99999 hours).
- c. E-mail Notification: Automatically route e-mail messages to five individual e-mail addresses. Within the body text of the e-mail, include a link that will automatically redirect the user to the associated panels' status Web page.

B. Timing Unit:

1. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
2. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
3. 16 independent schedules, each having 24 time periods.
4. Schedule periods settable to the minute.
5. Day of week, day of month, day of year with one-time or repeating capability.
6. 32 special date periods.

C. With eight inputs, each configurable to the following parameters:

1. Normally open, normally closed, two-wire maintained toggle, two-wire momentary toggle, two-wire momentary on, two-wire momentary off, or three-wire momentary operation.
2. On and off-delay timers for local override operation, adjustable from five minutes to 12 hours. Local override shall be by field-installed two-wire momentary toggle switch.

2.7 CONTROL NETWORK

- A. Panel Controllers: Networked with other DDC system for HVAC controllers in a peer-to-peer configuration using Ethernet 10Base-T network.
- B. Compliance with ASHRAE 135: Controllers shall support serial MS/TP and Ethernet IP communications, and shall be able to communicate directly via DDC system for HVAC RS-485 serial networks and Ethernet 10Base-T networks as a native device.

2.8 MANUAL SWITCHES AND PLATES

- A. Keypads: Programmable, designed to control functions associated with the equipment of this Section. The user shall be able to control any system output device.
- B. Push-Button Switches: Modular, momentary-contact, low-voltage type.
 1. Match color specified in Section 262726 "Wiring Devices."
 2. Integral green neon pilot light to indicate when circuit is on.
 3. Internal white neon locator light to illuminate when circuit is off.
- C. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Section 262726 "Wiring Devices."

- D. Wall Plates: Single and multigang plates as specified in Section 262726 "Wiring Devices."
- E. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.9 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 and Class 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Twisted-Pair Data Cable: Category 6. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install panelboards and accessory items according to NEMA PB 1.1.
- B. Mounting: Plumb and rigid without distortion of box. Mount flush panelboards uniformly flush with wall finish.
- C. Install filler plates in unused spaces.
- D. Wiring in Panelboard Cutters: Arrange conductors into groups, and bundle and wrap with wire ties after completing load balancing.
- E. Two or three pole circuit breakers shall be common trip type. Single pole breakers with handle ties will not be permitted.
- F. Tandem circuit breakers will not be permitted.
- G. Provide ground buses in panelboards as indicated on the Drawings. Ground bus shall be similar in all respects to neutral bus.
- H. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289, *Application Guide for Ground Fault Circuit Interrupters*.

- I. Branch circuit breakers (or switches) serving clocks, telephone and communications equipment, refrigerators, exit signs, fire alarm system controls, etc., shall be equipped with lock clips to prevent accidental operation.
- J. Height: Six-feet, six-inches to top of panelboard; install panelboards taller than 6 feet with bottom no more than 4 inches above the floor. Top breaker maximum height not to exceed 6 feet 8 inches.
- K. Do not energize or connect service-entrance equipment and panelboards to their sources until surge protective devices are properly installed and connected.

3.2. IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section 260553, *Electrical Identification*.
- B. Panelboard Nameplates: Label each panelboard with engraved laminated plastic or metal nameplates mounted with corrosion-resistant screws.
- C. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section 260553, *Electrical Identification*.
- D. Panelboard Circuit Directories: Provide a typewritten directory, indicating plainly what each branch circuit of the panelboard serves and where. Provide additional information as required by NEC. Spaces and spare breakers shall be written in pencil. Copying of Contract Drawing Panel Schedules and Descriptions shall not be acceptable. Circuit directory shall reflect final circuit connections, loads and locations after balancing of panelboard loads.

3.3. GROUNDING

- A. Make equipment grounding connections for panelboards as indicated.
- B. Provide ground continuity to main electrical ground bus as indicated.

3.4. CONNECTIONS

- A. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not published, use those specified in UL 486A and UL 486B.
- B. Neutral and ground conductors shall be isolated and terminated only at their respective bus bars. There shall only be one neutral-ground connection in service-entrance equipment by means of a removable main bonding jumper. Neutral and ground terminations at one bus bar shall not be acceptable.

3.5. FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Make insulation-resistance tests of each panelboard bus, component, and connecting supply, feeder, and control circuits.
2. Make continuity tests of each circuit.
3. Provide set of Contract Documents to test organization. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in the original Contract Documents.

B. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing.

C. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded case circuit breakers. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units, and retest.
3. Reports by Testing Organization: Report written reports of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made.
4. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating results of tests and inspections, responsible organization and person, and date.
5. Protective Device Ratings and Settings: Verify indicated ratings and settings to be appropriate for final system configuration and parameters. Where discrepancies are found, recommend final protective device ratings and settings. Use accepted ratings or settings to make the final system adjustments.

D. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
2. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
3. Check panelboard mounting, area clearances, and alignment and fit of components.
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
5. Perform visual and mechanical inspection and related work for over-current protective devices.
6. Verify that all neutral conductors are bonded to the system ground at the service-entrance prior to installation of the surge protective device.
7. Verify that neutral-ground bonds do not exist at locations that are not service entrances or separately derived power sources.

- E. Electrical Tests: Include the following items performed in accordance with manufacturer's instructions:
 - 1. Insulation resistance test of buses and portions of control wiring that is disconnected from solid-state devices. Insulation resistance less than 100 megohms is not acceptable.
 - 2. Ground resistance test on system and equipment ground connections.
 - 3. Test main and subfeed over-current protective devices.
 - 4. Test phase loss relay(s) at panelboards to verify that phase loss relays are fully operational.
- F. Retest: Correct deficiencies identified by tests and observations and provide retesting of panelboards by testing organization. Verify by the system tests that the total assembly meets specified requirements.

3.6. ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Division 16 Section 260573, *Short Circuit Analysis, Coordination Study, and Arc Flash Hazard Analysis*.
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 - 1. Measure as directed during period of normal system loading.
 - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 - 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.7. PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.8. CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatter and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

END OF SECTION

DIVISION 26 SECTION 26 25 20
ROLL UP GENERATOR TERMINATION CABINET
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NOT FOR BID

SECTION 26 25 50 – ROLL UP GENERATOR TERMINATION CABINET

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 SCOPE

- A. The Contractor shall furnish and install, where indicated, a wall mounted termination cabinet for use as an intermediate termination point between the customer supplied roll up generator and the disconnecting means servicing the loads, and as shown on the contract drawings.

1.3 ACTION SUBMITTALS

- A. Product Data: Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings:
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Include wiring diagrams for power, signal, and control wiring.
 - 5. Cable terminal sizes, line lug requirements, load lug requirements, conduit entry/exit locations.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Performance 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.

1.5 CLOSEOUT SUBMITTALS

- A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- 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. UL (Underwriters Laboratories, Inc.) Standards
- D. Comply with NFPA 70.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations:
 - 1. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet (2000 m).

1.8 GUARANTEE/WARRANTY

- A. The equipment installed under this contract shall be left in proper working order. Replace, without additional charge, new work or material which develops defects from ordinary use within one year.
- B. New materials and equipment shall be guaranteed against defects in composition, design or workmanship. Guarantee certificates shall be furnished.

PART 2 - PRODUCTS

2.1 GENERATOR TERMINATION CABINET

- A. Manufacturers: Subject to compliance with requirements, provide products by TRYSTAR or approved equal.

2.2 GENERAL REQUIREMENTS

- A. Docking station shall include 16 Series Camlok Panel Mounts for use as connection to Portable Generator.

- B. Entire package must be listed to ETL or UL 1008 Standards. UL listing of individual components is not acceptable.

- C. Enclosures:

1. NEMA 3R rain-tight, 304 GA aluminum enclosure

- a. Pad-lockable front door shall include a hinged access plate at the bottom for entry of cables from portable generator or portable load bank. NEMA 3R integrity shall be maintained with access plate open for cable entry.
- b. Front and side through a front access panel shall be accessible for maintenance.
- c. Top, side, and bottom through a front access panel shall be accessible for permanent cabling.
- d. Paint after fabrication. All exterior and interior steel surfaces shall be properly cleaned and provided with a rust-inhibiting phosphatized coating and finished with ANSI 61 light gray polyester powder paint.

2. Front Cover:

- a. Hinged.
- b. Gasketed.
- c. Pad-lockable latch.

- D. Phase, Neutral, and Ground Buses:

1. Material: Silver-plated copper.
2. Equipment Ground Bus: bonded to box.
3. Ground Bus: 50% of phase size.
4. Neutral Bus: Neutral bus rated 100 percent of phase bus.
5. Round edges on bus.

- E. Temporary generator connectors shall be Camlok style mounted on gland plate.
 - 1. Camlok shall be color coded according to system voltage
 - a. A phase – Black or Brown
 - b. B phase – Red or Orange
 - c. C phase – Blue or Yellow
 - d. N Neutral – White
 - e. G Ground – Green
- F. Temporary connectors shall include protective flip lids to prevent accidental contact.
- G. Permanent connectors shall be broad range set-screw type, located behind an aluminum barrier.
- H. Short Circuit & Withstand Rating
 - 1. Shall be minimum 65KAIC unless otherwise indicated on drawings.
- I. Voltage & Phase shall be as indicated on the drawings.
- J. Amperage rating of unit shall be as indicated on the drawings.
- K. Phase Rotation Monitor Device:
 - 1. Phase monitoring relay to be Siemens 3U4512- Arkzo or equal.

2.3 ADDITIONAL OPTIONS

- A. The following additional options shall be provided:
 - 1. Two Wire Auto Start
 - 2. Listed Monitoring Device

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive Generator Termination cabinet for compliance with manufacturer's tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install anchor bolts to elevations required for proper attachment to Generator Termination cabinet.

- B. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to concrete per manufacturer's recommendations. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."
- B. Label with a nameplate complying with requirements for identification specific in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Tests and Inspections shall include the following:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, when 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 Generator Termination cabinet. Remove front panels so joints and connections are accessible to portable scanner.
- B. Generator termination cabinet will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports, including a certified report that identifies Generator Termination cabinet and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- D. Manufacturer's Field Start-up: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections prior to turn-over to Owner.

END OF SECTION

DIVISION 26 SECTION 26 27 26
WIRING DEVICES
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SECTION 26 27 26 - WIRING DEVICES

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 Section includes the following:

1. Straight-blade receptacles and associated device plates.
2. GFCI receptacles.
3. Locking receptacles.
4. Tamper-Resistant receptacles.
5. Weather-Resistant receptacles.
6. Toggle switches.
7. Wall-box dimmer switches.
8. Pendant cord connector devices.
9. Cord and plug sets.
10. Emergency pushbuttons.
11. Floor service outlets, poke-through assemblies, and multioutlet assemblies.

- B. Related sections include the following:

1. Section 260923 – Lighting Control Devices

1.3 DEFINITIONS

- A. EMI: Electromagnetic Interference.
- B. GFCI: Ground-Fault Circuit Interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-Frequency Interference.
- E. UTP: Unshielded Twisted Pair.
- F. TR: Tamper-Resistant.
- G. WR: Weather-Resistant.

1.4 SUBMITTALS

- A. Product Data: For each product specified, indicating configurations, finishes, dimensions, and manufacturer's instructions.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Field quality-control test reports.
- D. Maintenance Data: For materials and products to include in maintenance manuals specified in Division 01.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- B. Comply with NFPA 70.
- C. Comply with NECA Standard of Installation.
- D. Codes: Provide wiring devices conforming to the following:
 - 1. American National Standards Institute (ANSI): Provide lugs and receptacle devices constructed in accordance with ANSI C13, *Attachment Plugs and Receptacles, Dimensions of*.
 - 2. Institute of Electrical and Electronic Engineers (IEEE): Construct and install wiring devices in accordance with requirements of IEEE 241, *Recommended Practice for Electric Power Systems in Commercial Building*.
 - 3. National Electrical Manufacturers Association (NEMA): Provide wiring devices constructed and configured in accordance with the requirements of
 - a. WD1: General Requirements for Wiring Devices
 - b. WD2: Semiconductor Dimmers for Incandescent Lamps
 - c. WD5: Special Purpose Wiring Devices
 - d. WD6: Wiring Devices - Dimensional Requirements.
 - 4. National Fire Protection Association (NFPA): Comply with NFPA 70, *National Electrical Code*, as applicable to construction and installation of electrical wiring devices.
 - 5. Underwriters Laboratories, Inc. (UL): Provide wiring devices which are UL listed and comply with the requirements of:
 - a. 20: General-Use Snap Switches.
 - b. 498: Attachments, Plugs and Receptacles
 - c. 514A: Metallic Outlet Boxes.
 - d. 514B: Fittings for Conduit and Outlet Boxes.
 - e. 514C: Non-Metallic Outlet Boxes, Flush-Device Boxes, and Covers
 - f. 943: Ground-Fault Circuit Interrupters

1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Wiring Devices:
 - a. Hubbell, Inc.; Wiring Devices Div.
 - b. Pass & Seymour/Legrand; Wiring Devices Div.
 - c. Leviton Manufacturing Co., Inc.
 - d. Cooper Wiring Devices
 - 2. Multioutlet Assemblies:
 - a. Airey-Thompson Co.
 - b. Wiremold.
 - c. Hubbell Inc. Wiring Devices
 - d. American Electric
 - 3. Emergency Pushbuttons
 - a. Safety Technology International, Inc. (STI)

2.2 STRAIGHT BLADE RECEPTACLES

- A. General Requirements
 - 1. Straight blade receptacles shall have the following basic features:
 - a. Tamper-Resistant.
 - b. One-piece brass mounting strap with integral ground for low resistance of fault currents.
 - c. Auto-ground clip to assure positive ground.
 - d. Impact-resistant nylon/thermoplastic face and base housing.
 - e. #10 large head brass terminal and ground screws.

B. Duplex Convenience Receptacles

1. Duplex convenience receptacles shall be extra heavy-duty, specification grade, 20A, 125V.
2. Comply with NEMA WD-1, NEMA WD-6 configuration 5-20R, UL 498 and Federal Specification W-C-596.
3. Hubbell HBL5362, or approved equal by acceptable manufacturer.

C. Single Convenience Receptacles

1. Single convenience receptacles shall be extra heavy-duty, specification grade, 20A, 125V.
2. Comply with NEMA WD-1, NEMA WD-6 configuration 5-20R, UL 498 and Federal Specification W-C-596.
3. Hubbell HBL5361, or approved equal by acceptable manufacturer.

D. Special Purpose Receptacles

1. Special purpose receptacles shall have ratings and NEMA configurations as indicated on the Drawings, or as required to match equipment plug configuration, and shall be back with device plate to match outlet type.

E. Controlled/Switched Receptacle

1. Controlled/Switched Receptacles shall be 125 V, 20 A and comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498 Supplement sd, and FS W-C-596.
2. Hubbell; BR20* or approved equal by acceptable manufacturer.
3. Provide with controlled receptacle marking with custom engraving/pad printing on device plate device with the words "Controlled Receptacle".

2.3 GFCI RECEPTACLES

A. General Requirements

1. GFCI receptacles shall have the following basic features:
 - a. Solid-state ground-fault sensing and signaling.
 - b. Trip time of 0.25 seconds (nominal).
 - c. Trip threshold of +/- 5mA.
 - d. Indicator light that is lighted when device is tripped.
 - e. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.
 - f. Auto-ground clip to assure positive ground.
 - g. Impact-resistant nylon/thermoplastic face and base housing.
 - h. #10 large head brass terminal and ground screws.

B. Duplex GFCI Receptacles

1. Duplex GFCI receptacles shall be extra heavy-duty, specification grade, 20A, 125V.
2. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, UL 498 and Federal Specification W-C-596.
3. Hubbell BR20*, or approved equal by acceptable manufacturer.

C. Weather-Resistant Duplex GFCI Receptacles

1. Weather-resistant duplex GFCI receptacles shall be extra heavy-duty, specification grade, 20A, 125V with the following features:
 - a. "WR" marking on face as required by UL Standard.
 - b. UV-resistant nylon face for longer life under adverse environmental conditions.
2. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, UL 498 and Federal Specification W-C-596.
3. Hubbell GFTR20, or approved equal by acceptable manufacturer.

2.4 LOCKING RECEPTACLES

A. Single Convenience Receptacles

1. Single convenience receptacles shall be extra heavy-duty, specification grade, 20A, 125V: Comply with NEMA WD1, NEMA WD6 configuration 15-20R, UL 498 and Federal Specification W-C-596.

B. Special Purpose Receptacles

1. Special purpose receptacles shall have ratings and NEMA configurations as indicated on the Drawings, or as required to match equipment plug configuration, and shall be black with device plate to match outlet type.

2.5 SWITCHES

A. General Requirements

1. Switches shall have the following basic features:
 - a. Heavy-gauge one-piece copper alloy contact arm.
 - b. Fast "make" and positive "break" to minimize arcing.
 - c. Heavy-duty bumper pads for quiet operation.
 - d. High strength thermoplastic polycarbonate toggle.
 - e. Overlapped silver alloy contacts for long life and heat dissipation.
 - f. Nickel-plated steel strap with integral ground.
 - g. Auto-ground clip to assure positive ground.

B. Toggle Switches

1. Toggle switches shall be quiet-type, extra heavy-duty, industrial grade, 120/277V, 20A: Comply with NEMA WD 1, UL 20 and Federal Specification W-S-896.
2. Hubbell HBL1221 (single-pole), HBL1222 (two-pole), HBL1223 (three-way), HBL1224 (four-way), or approved equal by acceptable manufacturer.

C. Pilot Lighted Switches

1. Pilot lighted switches shall be quiet-type, extra heavy-duty, industrial grade, 120/277V, 20A with the following features:
 - a. Red lighted toggle, lit when switch is "on".
2. Comply with NEMA WD 1, UL 20 and Federal Specification W-S-896.
3. Hubbell PS1221PL (single-pole), HBL1222PL (two-pole), HBL1223PL (three-way), or approved equal by acceptable manufacturer.

D. Key (Locking) Switches

1. Key (locking) switches shall be quiet-type, extra heavy-duty, industrial grade, 120/277V, 20A with the following features:
 - a. Furnished with key for locking switch.
2. Comply with NEMA WD 1, UL 20 and Federal Specification W-S-896.
3. Hubbell HBL1221L (single-pole), HBL1222L (two-pole), HBL1223L (three-way), HBL1224L (four-way), or approved equal by acceptable manufacturer.

2.6 WALL-BOX DIMMER SWITCHES

A. General Requirements

1. Wall-box dimmer switches shall have the following basic features:
 - a. Modular, full-wave, solid-state units with audible frequency and EMI/RFI suppression filters.
 - b. Single-pole or three-way switching.
 - c. Comply with UL 1742.
2. Wall-box dimmer switches shall be sized by the Contractor to serve the load indicated on the Contract Drawings.

2.7 WALL-BOX TIMER SWITCHES

A. Astronomic Programmable Timer

1. Description: 24-Hour Programmable Timer.
2. Features:
 - a. Real time clock with day/date calendar.
 - b. Lighted manual ON/OFF switch for visibility in darkened rooms.
 - c. Easy to read LED display.
 - d. Programming buttons accessible without removing wall plate.
 - e. Eight programs can be assigned to any day or combination of days of the week.
 - f. Automatically calculates sunrise and sunset times based on latitude and longitude.

- g. Audible or visible occupant warning before automatic off.
- h. Power failure memory.
- i. Zero crossing circuitry.
- j. cULus listed.
- k. Conforms to NEMA WD-1 and WD-6.
- l. 5-year warranty.

3. Ratings:

- a. 0-800W, 1/6HP at 120 VAC, 60 Hz.
- b. 0-1200W, 1/6HP at 277 VAC, 60 Hz.

4. Loads:

- a. Lighting: Incandescent, fluorescent, compact fluorescent (CFL), magnetic low-voltage (MLV), electronic low-voltage (ELV).
- b. Motors: Up to 1/6 horsepower.

5. Basis of Design: Pass & Seymour Catalog No. RT24.

2.8 FINISHES

- A. Wiring device catalog numbers in Section text do not designate device color. Device colors shall be as follows, unless otherwise indicated elsewhere in the Specifications and Drawings or as required by NFPA or device listing:

- 1. Wiring Devices connected to Normal Power System: Ivory.
- 2. Wiring Devices connected to Computer Power System: Gray.
- 3. Wiring Devices connected to Emergency Power System: Red.
- 4. Special Receptacles: Black.

2.9 DEVICE PLATES

- A. Device plates shall be provided for all switches and receptacles. Device plates shall be as manufactured to match type of single device, to fit devices which are ganged together, and they shall be same manufacturer as wiring devices with finish as follows:

- 1. Material for Finished Spaces: 0.04-inch thick, Type 430 satin finished stainless steel.
- 2. Material for Unfinished Spaces: Galvanized steel.
- 3. Color: Matches wiring device, except as otherwise indicated. To match existing device plates.
- 4. Plate-Securing Screws: Metal with heads colored to match plate finish.

- B. Material for Damp Locations: Heavy-duty die-cast zinc/aluminum construction listed and labeled for use in "wet locations." All components shall have baked-on electrostatic, polyester, power paint finish for superior corrosion resistance. Covers for receptacles shall be equipped with one or more lift cover(s) equipped with stainless steel springs. Covers for toggle switches shall be equipped with actuating levers and shall mount directly over the switch. Covers for receptacles

shall comply with 2011 NEC Article 406.9(A). Covers for switches shall comply with 2011 NEC Article 404.4.

1. Duplex Receptacle, 2 Self-Closing Lids – Pass & Seymour Model No. CA8GH or approved equal
2. GFCI Receptacle, 1 Self-Closing Lid – Pass & Seymour Model No. CA26GH (Horizontal) and Pass & Seymour Model No. CA26GV (Vertical), or approved equal.
3. Toggle Switch – Pass & Seymour Model No. CA1GL or approved equal.
4. Toggle switch, lockable cover – Crouse-Hinds Model No. DS185, or approved equal.

C. Material for Wet Locations: Heavy-duty die-cast zinc/aluminum construction with gasketed, hinged lockable lid, designed to be weatherproof while the device is in use, and listed and labeled for use in “wet locations.” All components shall have baked-on electrostatic, polyester, powder paint finish for superior corrosion resistance. Covers for receptacles shall be self-closing per UL514C42.3, be equipped with stainless steel springs, and shall have a cam action latch for secure closure. Covers for toggle switches shall be equipped with actuating levers and shall mount directly over the switch. Covers for receptacles shall comply with 2011 NEC Article 406.9(B). Covers for switches shall comply with 2011 NEC Article 404.4.

1. Duplex/GFCI Receptacle - Pass & Seymour Model No. WJUCAS or approved equal.
2. Toggle switch – Pass & Seymour Model No. CA1GL, or approved equal.
3. Toggle switch, lockable cover – Crouse-Hinds Model No. DS185 or approved equal.

D. Device plates for receptacles on emergency circuits shall have a red finish.

E. Provide jumbo size plates for outlets installed in masonry walls.

2.10 PROTECTIVE WIRE GUARDS

A. Provide protective wireguards over devices subject to physical damage. All devices installed in mechanical and electrical rooms and on the exterior of the building shall be provided with protective guards. Protective guards shall be manufacturer's recommended product for the device being protected or a suitable guard as manufactured by American Time & Signal Company (800-328-8996), Safety Technology International (STI) (800-888-4784), or Institutional Systems Services Corporation (800-524-0537).

B. Devices to be provided with protective guards include, but are not limited to, the following:

1. Lighting Fixture
2. Clock
3. Bells
4. Fire Alarm Pull Stations
5. Thermostats
6. Smoke/Heat Detectors
7. Speakers
8. Fire Alarm Audio/Visual Devices (Strobe, Horn, etc...)
9. Exit Signs
10. Emergency Lights
11. Telephones
12. Data Outlets

13. Security Devices/Motion Detectors
14. Wiring Devices
15. Emergency Shut-Off Stations
16. Other Devices as required by Owner

- C. Guard shall be fabricated from ¼-inch (9-gauge) cold-rolled steel rods, welded together with mounting tabs. Guard shall be finished with a powder-based epoxy to protect against corrosion. Finish color shall match the finishes for the area being installed, except guards for fire alarm devices shall be red finish color.
- D. Protective Devices shall be considered incidental to the product installed in an area subject to damage as indicated on the drawings and shall be provided at no additional cost to the Owner.

2.11 PENDANT CORD/CONNECTOR DEVICES

- A. Description: Matching, locking type, plug and receptacle body connector, NEMA WD 6, Configurations L5-20P and L5-20R, Heavy-Duty grade.
1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
 2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.12 CORD AND PLUG SETS

- A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
1. Cord: Rubber-insulated, stranded-copper conductors, with type SOW-A jacket. Green-insulated grounding conductor, and equipment-rating ampacity plus a minimum of 30 percent.
 2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.13 EMERGENCY PUSH BUTTONS

- A. General:
- Emergency pushbuttons shall be Stopper Station with Bopper Stopper cover, as manufactured by Safety Technology International, Inc. (STI), or approved equal.
- B. Features:
1. Button activation shall be Push-to-Activate, Turn-to-Reset.
 2. Interchangeable or replaceable Normally Open (N.O.) or Normally Closed (N.C.), Single-Pole, Single-Throw (SPST) gold-plated contact blocks rated for three (3) amps at 600 VAC or one (1) amp at 250VDC.

3. Standard switch shall include one N.O. and one N.C. contact.
4. Switch shall hold up to three (3) sets of isolated contacts.

C. Construction:

1. Housing shall be molded of polycarbonate rated for temperature range of -40 degrees to 250 degrees Fahrenheit.
2. Housing color shall be yellow, unless otherwise indicated.
3. Pushbutton shall be provided with stainless steel backplate and matching polycarbonate spacer (as required), both having a 5VA flammability rating.

D. Labeling:

1. Pushbuttons shall be provided with a vinyl label that is customized to suit each application, including, but not limited to the following:
 - a. "Emergency Power Off"
 - b. "Water Heater Shut-Down"
 - c. "Emergency Utilities Off" (used when shutting off multiple utilities, i.e. power, air, water, and/or gas)

E. Cover

1. Pushbutton covers shall have the following features:
 - a. Molded from thick clear polycarbonate material.
 - b. UV stabilized.
 - c. 94V-2 flammability rating.
 - d. Stainless steel torsion spring to maintain cover in a closed position.
 - e. Mounting hardware and gasket.
 - f. Lifetime guarantee against breakage of polycarbonate from normal use.

F. Quality Assurance

1. Pushbuttons shall be tested and approved or listed by:
 - a. Underwriter Laboratories (UL) and Canadian Underwriter Laboratories No. S7255.
 - b. Complies with UL 2017.
 - c. UL listed for indoor and outdoor use, when used with appropriate weather cover.
2. Pushbuttons shall be ADA Compliant.

G. Warranty

1. Pushbuttons shall be provided with lifetime guarantee against breakage of polycarbonate in normal use.
2. Pushbuttons shall be provided with one year guarantee on electro-mechanical and electronic components.

2.14 FLOOR SERVICE FITTING

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartments: Barrier separates power from voice and data communication cabling.
- C. Service Plate: Rectangular, solid brass with satin finish.
- D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.
- E. Voice and Data Communication Outlet: Two modular, keyed, color-coded, RJ-45 Category 6 jacks for UTP cable.

2.15 MULTIOUTLET ASSEMBLIES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers of wiring products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Hubbell Incorporated; Wiring Device-Kellems.
 - 2. Wiremold Company (The).
- B. Components of Assemblies: Products from a single manufacturer designed to use as a complete, matching assembly of raceways and receptacles. Provide in lengths indicated on the Drawings, with wiring devices in quantities and spacing indicated. Provide suitable service plates and standard receptacle plates. Provide complete with all fittings and accessories required for a complete system.
- C. Raceway material: Metal with manufacturer's standard finish. Provide power and telecommunications wiring to all devices indicated as multioutlet assemblies. Feed locations and wiring runs shall be configured such that 40 percent of all capacities are not exceeded.
- D. Raceways shall be provided with full length divider for separation of power and communications devices of and wiring.
- E. Devices shall be type and color as previously specified. Label, circuit number on inside of plate of each power device.

2.16 FLOOR BOXES

- A. Available Products: Subject to compliance with requirements, products may be incorporated into the Work to include, but not be limited to, the following:
 - 1. Wiremold Company (The).
 - 2. Hubbell, Incorporated.
- B. Provide floor boxes as detailed on the Drawings, complete with fittings, devices, covers, etc. Floor boxes shall be cast iron for slab-on-grade applications.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of existing conditions before starting work.
- B. Verification of Conditions: Verify that field measurements, surfaces, substrates and conditions are as required, and ready to receive Work.
 - 1. Verify that outlet boxes are installed at proper height.
 - 2. Verify that wall openings are neatly cut and will be completely covered by wall plates.
 - 3. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.
- C. By beginning Work, accepts conditions and assume responsibility for correcting unsuitable conditions encountered at no additional cost to the Owner.

3.2 INSTALLATION

- A. Install devices and assemblies plumb, level, and secure.
- B. Install wall plates when painting is complete.
- C. Install wall dimmers to achieve indicated rating after derating for grouping as instructed by manufacturer.
- D. Do not share neutral conductor on load side of dimmer.
- E. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and grounding terminal of receptacles on top or as required by the local Authority Having Jurisdiction. Exception: Mount exterior GFI weatherproof duplex receptacles horizontally with grounding terminals on the left, as required by the local Authority Having Jurisdiction. Group adjacent switches under single, multi-gang wall plates.
- F. Protect devices and assemblies during painting.
- G. Emergency shut-down toggle switches for boilers shall be provided at all means of egress from rooms in which boilers are installed. Boiler shut-down switches shall be clearly identified and shall be equipped with illuminated toggle.
- H. Receptacles on emergency circuits shall be clearly identified, with a circuit label indicating panelboard and circuit number.
- I. 15 ampere and 20 ampere, 125 volt and 250 volt, non-locking type receptacles installed in damp or wet locations shall be listed weather-resistant type in accordance with 2014 NEC Article 406.9(A) and 406.9(B).
- J. All 15 ampere and 20 ampere, 125 volt, single-phase, non-locking type receptacles installed in the following locations shall have GFCI protection for personnel, in accordance with 2017 NEC Article 210.8(B).
 - 1. Bathrooms/Toilet Rooms

2. Kitchens
 3. Rooftops
 4. Outdoors
 5. Within six (6) feet (1.8m) of sinks, plumbing fixtures and water piping.
 6. Indoor wet locations.
- K. Where multiple receptacles are indicated on the Contract Drawings as GFCI type receptacles, each device must be a GFCI type receptacle. Protecting standard receptacles downstream from one GFCI receptacle is not acceptable.
- L. Switches shall be located as indicated on the drawings, arranged singular or in gangs within 18" of the door jam on the strike side of the door openings. Verify the door swings with the Architectural Drawings prior to rough-in.
- M. Install life safety system switches separate from the normal power switches. Do not include in the multiple gang configuration.
- N. Switch and receptacle combinations shall be as above in a 2-gang box where both are of the same voltage. Provide separate boxes where different voltages are present.
- O. All switches in Mechanical Rooms, Electrical Rooms and other such places shall be a lighted handle, single-pole light switch(es) as required.
- P. Install receptacles with ground pole in position top unless otherwise required by local authority having jurisdiction.
- 3.3 IDENTIFICATION
- A. Comply with Division 26 Section 260553, *Electrical Identification*.
1. Switches: Where three or more switches are ganged, and elsewhere as indicated, identify each switch with approved legend engraved on wall plate. Light switches shall be labeled as to lights controlled and with circuit number and panel identification.
 2. Receptacles: Identify panelboard and circuit number from which served. Use machine-printed, pressure-sensitive, abrasion-resistant label tape on face of plate and durable wire markers or tags within outlet boxes. Protect label from damage during construction. Replace all damaged and unclear labels.
 3. Mark all conductors with the panel and circuit number serving the device at the device.
 4. Mark the panel and circuit number serving the device on the back side of the device plate with a permanent marking system, machine-generated, that does not show through the front of the plate.
- 3.4 CONNECTIONS
- A. Connect wiring device grounding terminal to outlet box with bonding jumper.
- B. Connect wiring device grounding terminal to branch-circuit equipment grounding conductor.

- C. Tighten electrical connectors and terminals according to manufacturers published torque-tightening values. If manufacturers torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

- A. Test wiring devices for proper polarity, continuity, short circuits, and ground continuity. Operate each device at least six times.
- B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
- C. Replace damaged or defective components.

3.6 CLEANING

- A. Internally clean devices, device outlet boxes, and enclosures. Repair stained or improperly painted wall plates or devices.

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DIVISION 26 SECTION 26 28 13
FUSES
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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. This Section includes the following:
 - 1. Fuses.
 - 2. Spare Fuse Cabinet.
- B. The Electrical Contractor shall provide a complete set of fuses for all electrical equipment on the project as indicated on the Contract Documents. Final test and inspections shall be made prior to energizing the equipment.

1.3 PERFORMANCE REQUIREMENTS

- A. Select fuses to provide appropriate levels of short circuit and overcurrent protection for components such as wire, cable, bus structures, and other equipment. Provide system to ensure that component damage is within acceptable levels during a fault.
- B. Select fuses to coordinate with time-current characteristics of other overcurrent protective elements, such as other fuses, circuit breakers, and protective relays. Provide system to ensure that device closest to fault operates.

1.4 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 01 Specification Sections.
- B. Product Data for each fuse type specified. Include the following:
 - 1. Product literature, including descriptive data and time-current curves.
 - 2. Let-through current curves for fuses with current-limiting characteristics
 - 3. Coordination charts and tables and related data.
- C. Field test reports indicating and interpreting test results.
- D. Maintenance data for tripping devices to include in the Operation and Maintenance Manual specified in Division 01.

- E. Record the equipment nameplate rating and actual fuse rating and location of fuses on the record drawings.
- F. Provide a complete short circuit coordination study report as required to select fuses to protect equipment.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain fuses from one source and by a single manufacturer.
- B. Comply with NFPA 70 for components and installation.
- C. Listing and Labeling: Provide fuses specified in this Section that are listed and labeled.
 - 1. The terms *Listed* and *Labeled* as defined in the National Electrical Code, Article 100
 - 2. Listing and Labeling Agency Qualifications: A *Nationally Recognized Testing Laboratory* (NRTL) as defined in OSHA Regulation 1910.7.
 - 3. Comply with National Electrical Manufacturer's Association (NECA) *Low Voltage Cartridge Fuses*.
 - 4. Comply with IEC269.
 - 5. Comply with CANENA Standard 248.
 - 6. Comply with UL 198.

1.6 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
 - 1. Spare Fuses: Furnish quantity equal to 20 percent of each 600 ampere and small fuse type and size installed, but not less than one (1) set of three (3) of each type and size. (Provide three (3) of each 601 Ampere and larger fuse type and size installed.)
 - 2. Fuse Pullers: Furnish two (2) fuse pullers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering fuses to be incorporated into the Work include, but are not limited to, the following:
 - 1. Cooper Industries Inc. Bussmann Div.
 - 2. Eagle Electric Mfg, Co. Inc.
 - 3. Ferraz Corp
 - 4. General Electric Co; Wiring Devices Div.
 - 5. Gould Shawmut.
 - 6. Tracor, Inc; Littelfuse, Inc. Subsidiary

- B. All fuses shall be of the same manufacturer to assure coordination.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU-1, nonrenewable cartridge fuse; class as specified or indicated; current rating as indicated; voltage rating consistent with circuit voltage.

2.3 SPARE FUSE CABINET

- A. Cabinet: Wall mounted, 0.05 inch (1.27) mm) thick steel unit with full length, recessed piano-hinged door with key coded cam lock and pull, and circuit voltage.
 - 1. Size: Adequate for orderly storage of spare fuses specified with 15 percent spare capacity minimum.
 - 2. Size: Adequate for orderly storage of spare fuses specified with 15 percent spare capacity minimum.
 - 3. Finish: Gray, baked enamel.
 - 4. Identification: Provide engraved nameplate to read "SPARE FUSES" in 1/2 inch letters on door. Refer to Division 26 Section, "Electrical Identification" for nameplate requirements.
 - 5. Fuse Pullers: For each size fuse.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine utilization equipment nameplate and installation instructions to verify proper fuse locations, sizes, and characteristics.
- B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Main Service: Class K, fast acting, 600 Volt, 601-6000 Amp, and 300 kA interrupting rating.
- B. Main Feeders: Class J time delay, 600Volt, 0-600 Amp, and 300 kA interrupting rating.
- C. Motor Branch Circuits: Class RK1, time delay, 250 Volt Class J Time Delay 600 Volt, 0-600 Amp, and 300 kA interrupting rating. Time delay fuses shall hold 500% of rated current for a minimum of 10 seconds.
- D. Other Branch Circuits: Class RK1, non-time delay, 250 Volt, Class J Time Delay 600 Volt, 0-600 Amp, and 300 kA interrupting rating.
- E. Provide fuses of type and rating recommended by equipment manufacturer for packaged and/or specialized equipment.

- F. Motor, transformer, feeder, and main service protection - 250 Volts or less:
1. Six hundred (600) ampere and less in interrupter switches, Class RK1, dual elements, time delay, 300 kA interrupting rating.
 2. Four hundred (400) to six hundred (600) ampere in bolted pressure switches, Class J, 300 kA interrupting rating.
- G. Motor, transformer, feeder, and main service protection - 600 volts or less; 600 ampere and less - Class RK-1, dual element, time delay, 300 kA interrupting rating.
- H. Six hundred (600) ampere to six thousand (6000) ampere fuses used for protection of services, mains and feeders, Class L, current-limiting, time delay, 300 kA interrupting rating, rms symmetrical. Fuses shall be time delay and shall hold 500 percent of rated current for a minimum of four (4) seconds, clear 20 times rated current in 0.01 second or less, UL listed.
- I. Six hundred ampere or less, installed ahead of breaker: Class RK1, time delay.
- J. Six hundred ampere or less, for general power circuits: Class J, time-delay, dual element, 300 kA interrupting rating. Time-delay fuses shall hold 500 percent of rated current for a minimum of 10 seconds and shall be UL listed.
- K. Fuse sizes for motor protection shall be chosen from fuse manufacturers published data and recommendations.
- L. Control circuits and lighting: Class CC, current limiting protection type, rated 0-30 amperes, 600 volts, and 200- kA interrupting rating.
- M. Motor Circuits: All individual motor circuits with full load ampere ratings (FLA) of 480 amperes or less shall be protected by Dual-Element Time-Delay Fuses. The following guidelines apply for motors protected by properly sized overload relays: Fuses for motors with a marked service factor not less than 1.15 shall be installed in ratings of 125% of motor full-load current (or next size larger if 125 percent does not correspond to a fuse size), except where high ambient temperatures prevail, or where the motor drives a heavy revolving part which cannot be brought up to full speed quickly, such as large fans. Under such conditions, the fuses may be 150 percent to 175 percent of the motor full-load current. For all other motors, (such as 1.0 service factor motors) fuses shall be sized in ratings of 115 percent of the motor full load current (or next size larger if 115 percent does not correspond to a fuse size), except as noted above. The following guidelines apply where fuses are used as the only overload protection for the motor:
1. For motors with 1.15 service factor or more, fuses should be sized at 125 percent of motor full-load current (or next size smaller if 125 percent does not correspond to a fuse size).
 2. For all other motors, fuses should be sized at 115 percent of motor full-load current (or next size smaller, if 115 percent does not correspond to a fuse size).
- N. Motor Controllers: NEMA and IEC Style motor controllers shall be protected from short-circuits by Dual-Element Time-Delay fuses in order to provide testing agency-witnessed Type 2 coordination for the controller. This provides *no damage* protection for the controller, under low and high level fault conditions, as required by IEC Publication 947-4. For IEC style controller, the fuses shall be installed in ratings to coordinate with the overload relays, such that the relay/fuse curves cross over at 7-10 times the IEC contactor current rating.

- O. Panelboards: The manufacturer shall supply equipment utilizing fully-rated and listed components. This equipment shall be tested, listed, and labeled for the available short-circuit current.

3.3 INSTALLATION

- A. Fuses shall not be installed until equipment is ready to be energized. This measure prevents fuse damage during shipment of the equipment from the manufacturer to the job site, or from water that may contact the fuse before the equipment is installed. Final tests and inspections shall be made prior to energizing the equipment. This shall include a thorough cleaning, tightening, and review of all electrical connections and inspection of all grounding conductors. All fuses shall be furnished and installed by the electrical contractor. All fuses shall be of the same manufacturer. Install fuses in fusible devices as indicated. Arrange fuses so fuse ratings are readable without removing fuse.
- B. Install spare fuse cabinet where indicated.
- C. Provide fuse clips as required.

3.4 IDENTIFICATION

- A. Install typewritten labels on inside door of each fused switch to indicate fuse replacement information.

END OF SECTION

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ENCLOSED SWITCHES AND CIRCUIT BREAKERS\
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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 Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes individually mounted switches and circuit breakers.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 26 Section 262726, *Wiring Devices* for attachment plugs and receptacles, and snap switches used for disconnect switches.
 - 2. Division 26 Section 262813, *Fuses* for fuses in fusible disconnect switches.
- C. Provide method of disconnection at all appliances, motors, equipment, etc., as required to comply with NEC (including Article 422-C, and Article 410-D).

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 01 Specification Sections.
- B. Product Data for disconnect switches, circuit breakers, and accessories specified in this Section.
- C. Product Data for switches, circuit breakers, and accessories specified in this Section. Include the following:
 - 1. Descriptive data and time-current curves.
 - 2. Let-through current curves for circuit breakers with current-limiting characteristics.
- D. Coordination charts and tables and related data.

- E. Wiring diagrams detailing wiring for power and control systems and differentiating between manufacturer-installed and field-installed wiring.
 - F. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
 - G. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 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.
 - H. 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.
 - I. Maintenance data for tripping devices to include in the operation and maintenance manual specified in Division 01.
 - J. Submit a schedule of equipment to indicate ratings of disconnects, fuses, circuit breakers, and other electrical characteristics for each item of equipment.
- 1.5 QUALITY ASSURANCE
- A. Testing Agency Qualifications: In addition to the requirements specified in Division 01 Section 014000, *Quality Control*, an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or shall be a full member company of the International Electrical Testing Association (NETA).
 - 1. Testing Agency Field Supervisor: Person currently certified by NETA or the National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3.
 - B. Source Limitations: Obtain disconnect switches and circuit breakers from one source and by a single manufacturer.
 - C. Comply with NFPA 70 for components and installation.

- D. Listing and Labeling: Provide disconnect switches and circuit breakers specified in this Section that are listed and labeled.
1. The Terms *Listed* and *Labeled*: As defined in the National Electrical Code, Article 100.
 2. Listing and Labeling Agency Qualifications: A *Nationally Recognized Testing Laboratory* (NRTL) as defined in OSHA Regulation 1910.7.
 3. Underwriters Laboratories (UL) listed equipment: UL 98 - Enclosed and Dead Front Switches, UL 50 - Cabinets and Boxes, UL489 - Molded Case Circuit Breakers and Circuit Breaker Enclosures, NEMA 250 - Enclosures for Electrical Equipment.
 4. Comply with ANSI and NEMA Standards for materials ratings.
 5. Replacement circuit breakers shall be obtained from the original manufacturer through an authorized factory distributor, complete with full factory warranty. Original manufacturer product data shall be submitted for review.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following. No other manufacturers are acceptable.
1. ABB-GE Electrification Equipment
 2. Eaton Corp.; Cutler-Hammer.
 3. Siemens Energy & Automation, Inc.

2.2 DISCONNECT SWITCHES

- A. Enclosed, Nonfusible Switch: Heavy duty, NEMA KS 1, Type HD, horsepower rated with lockable handle in the *OFF* position. Switch shall be provided with an override screw to permit opening front cover with switch in *ON* position.
- B. Enclosed, Fusible switch, 200 A and Smaller: Heavy duty, NEMA KS 1, Type HD, horsepower rated, clips to accommodate specified fuses, enclosure consistent with environment where located, handle lockable in the *OFF* position, with 2 padlocks, and interlocked with cover in *CLOSED* position. Switch shall be provided with an override screw to permit opening front cover with switch in *ON* position. Minimum fault current rating shall be 200,000 symmetrical rms amperes.
- C. Characteristics: Size, number of poles and ratings as indicated and to match load being served.
- D. Enclosure: NEMA KS 1, Type 1, with gray baked enamel finish, unless otherwise specified or required to meet environmental conditions of installed location. Enclosure shall be rated for 200,000 rms symmetrical amperes short circuit current.
1. Outdoor Locations: Type 3R, with top-hinged, attached with removable screws.
 2. Kitchen Areas: Type 4X, stainless steel, attached by molded hinges and Type 316 stainless steel hinge pins.
 3. Other Wet or Damp Indoor Locations: Type 4.

E. Accessories

1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit (fusible switches only): Provides rejection of other fuse types when Class R fuses are specified.
4. Auxiliary Contact Kit (where indicated on drawings or required for proper operation): One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Compression type, suitable for number, size, and conductor material.
7. Service-Rated Switches (where indicated on drawings or required for proper operation): Labeled for use as service equipment.

2.3 ENCLOSED CIRCUIT BREAKERS

- A. Enclosed, Molded-Case Circuit Breaker: NEMA AB 1, with lockable handle.
- B. Characteristics: Frame size, trip rating, number of poles, and auxiliary devices as indicated and interrupting rating to meet available fault current, minimum of 10,000 symmetrical rms amperes.
- C. Application Listing: Appropriate for application, including switching fluorescent lighting loads or heating, air-conditioning, and refrigerating equipment.
- D. Circuit Breakers, 200 A and Larger: Trip units interchangeable within frame size.
- E. Circuit Breakers, 400 A and Larger: Field adjustable, short-time and continuous-current settings.
- F. Lugs: Mechanical lugs and power-distribution connectors for number, size, and material of conductors indicated.
- G. Shunt Trip: Where indicated. Provide voltage rating as required.
- H. Accessories:
 1. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 3. Shunt Trip (where indicated on drawings or required for proper operation): Trip coil energized from separate circuit, with coil-clearing contact.
 4. Auxiliary Contacts (where indicated on drawings or required for proper operation): One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 5. Accessory Control Power Voltage (where indicated on drawings or required for proper operation): Remote mounted and powered; 120-V ac.

- I. Enclosure: NEMA AB 1, Type 1, unless otherwise specified or required to meet environmental conditions of installed location.
 - 1. Outdoor Locations: Type 3R.
 - 2. Kitchen Areas: Type 4X, stainless steel.
 - 3. Other Wet or Damp Indoor Locations: Type 4.
- J. Provide full capacity neutral lug or 200 full capacity neutral for non-linear loads and equipment grounding lug and isolated ground lug where isolated grounding is indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install disconnect switches and circuit breakers in locations generally as indicated, according to manufacturer's written instructions. 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 disconnect switches and circuit breakers level and plumb. Provide mounting brackets, wall bracing, and accessories as required.
- C. Install wiring between disconnect switches, circuit breakers, control, and indication devices.
- D. Connect disconnect switches and circuit breakers and components to wiring system and to ground as indicated and instructed by manufacturer.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 436B.
- E. Identify each disconnect switch and circuit breaker according to requirements specified in Division 26 Section 260553, *Electrical Identification*. All switches shall be provided with laminated plastic labels which clearly identify the equipment served.
 - 1. Each disconnect means shall be legibly marked as required by Code (including all disconnect units for motors, appliances, feeders, and branch(es)).
- F. Provide fuses for all fusible safety switches as indicated and required by the load being served. Coordinate fusing of disconnects with mechanical equipment electrical characteristics.
- G. Provide disconnect switches for all equipment as indicated and as required by the NEC. Where disconnect switches are specified and furnished with mechanical equipment, install one only. Coordinate devices furnished for mechanical equipment with Division 23 Drawings and Specifications.
- H. Weatherproof switches shall be provided for all locations exposed to the elements whether called for or not.

- I. Switches and circuit breakers shall be labeled for service entrance use, if so required, where used for service entrance whether called for or not.
- J. Switches and circuit breakers provided shall be suitable for:
 - 1. Circuit application voltage.
 - 2. Circuit application ampacity x 125 percent.
 - 3. One pole, two pole, three pole, solid neutral, ground connection, all as required by item served or as shown on the Drawings.
- K. Install circuit and motor disconnect switches unit circuit breakers as indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NEMA, and NECA's *Standard of Installation*, and in accordance with recognized industry practices.

3.2 FIELD QUALITY CONTROL

- A. Testing Agency: Provide the services of a qualified independent testing agency to perform specified field quality-control testing.
- B. Testing: After installing disconnect switches and breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.5 for disconnect switches and Section 7.6 for molded-case circuit breakers.
 - 2. Certify compliance with test parameters.
- C. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

3.3 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, *Short Circuit Analysis, Coordination Study, & Arc Flash Hazard Analysis*.

3.4 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, and abrasions.

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SECTION 26 28 61 – COMPANY SWITCHES

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 section includes work in the following spaces:
1. Auditorium
 2. Black Box
- B. The work of this Section includes all labor, materials, equipment and services necessary to provide company switches as shown on the Drawings and/or specified here.
- C. Related sections include the following:
1. Performance Lighting Systems
 2. Performance Lighting Systems Installation
 3. Common Work Results for Electrical
 4. Interior Lighting Fixtures
 5. Performance Lighting Fixtures
 6. Orchestra Lift and Chair Wagon System
 7. Rigging Systems and Controls
 8. Catwalks
 9. Commissioning of Electrical Systems

1.3 QUALITY ASSURANCE AND STANDARDS

- A. References to code, standards, specifications and recommendations of technical societies, trade organizations and government agencies shall refer to the latest edition of such publications adopted and published prior to submittal of the bid. All such codes and standards shall be considered a part of the specification as if they were fully included herein.
- B. Work and materials shall comply with the rules and recommendations of:
1. Prevailing national, state and local building codes.
 2. UL, CSA and CE Labels – where materials and equipment are available under the continuing inspection and labeling service of applicable independent product testing and certification services, provide such labels, materials, and equipment.
 3. National Fire Protection Associate (NFPA) Publication: National Electrical Code, NFPA70 as applicable to installation and construction of (1) switchboards and panelboards and (2) stage lighting and control equipment.
 4. NEMA Compliance pertaining to components of stage lighting equipment.

1.4 SUBMITTALS

A. Bid Submittals

1. Bill of materials: Identify parts by common industry standard numbers and descriptions.
2. Cut Sheets: Manufacturer's catalog datasheets of all products listed in bill of materials.
3. Statements:
 - a. Manufacturer agrees to warranty provisions.
 - b. Manufacturer confirms that submitted equipment's listings and labels comply with installed locations shown on drawings.
4. Projected Timetable: List time in weeks for following activities:
 - a. Shop drawing preparation
 - b. Fabrication
 - c. Shipping to site
 - d. System commissioning
 - e. As-built drawing preparation

B. Shop Drawings

1. Format: Uniform sheet size.
2. Binding: Bind shop drawings of more than five drawings.
3. Shop drawings shall include:
 - a. Pictorial drawings: All major components, sub-assemblies, part list, dimensions, material and finish notes, quality assurance listings.
 - b. Wiring diagrams: Components and interconnections to other components.
 - c. Bill of materials: Accessories and spare parts not drawn.
 - d. Not acceptable: Catalog cut sheets.
4. Review: Fabrication shall not commence until Theatre Consultant and Architect determine that the shop drawings are in compliance with design intent of Contract Documents.
5. Revisions: Resubmit as required.

C. Manuals

1. Format: Letter and/or tabloid size paper.
2. Binding: Standard 3-ring binder.
3. Electronic Format: PDF files on USB flash drive.
4. Manuals shall include:
 - a. System description.
 - b. Operation instructions, including safety measures.
 - c. Maintenance instructions, including recommended procedures and schedules for inspecting system components.
 - d. Catalog cut sheets for all purchased equipment.
 - e. Recommended spare parts list.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURER

- A. The equipment shall be manufactured by the following:
1. Electronic Theatre Controls
3031 Pleasant View Road

- Middleton, WI 53562
608.831.4116
2. Lex Products
401 Shippan Ave
Stamford, CT 06902
203 363 3738
 3. Union Connector
8182 Baymeadows Way West
Jacksonville, FL 32256
631 753 9550
- B. Substitution of manufacturer or parts shall not be allowed without prior approval of Architect, Electrical Engineer, Theatre Consultant, AV System Consultant or Owner. Substitutions shall only be accepted if, in the opinion of the Architect and/or Owner's representative, the new product is an equal or exceeds the specified product.
- C. When a manufacturer's product has been replaced by a newer model prior to shipment, the newer model shall be furnished provided the new model retains or exceeds all of the specified characteristics of the product specified herein.
- D. All equipment must be tested and labeled at factory prior to shipment.

2.2 COMPANY SWITCHES

- A. Company switches shall be from one of the following manufacturers:
1. Electronic Theatre Controls PowerSafe
 2. LEX Products PowerGATE
 3. Union Connector Company Switch w/Connection Chamber
- B. General
1. Company switches shall be a specialized power distribution panel for the connection of portable electrical equipment in theatres, auditoriums and other places of public entertainment.
 2. Enclosure dimensions shall not exceed 57" high x 28" wide x 12" deep.
 3. Enclosure shall have a NEMA 1 rating. NEMA 3 rated enclosures shall be available as an option, and provided as shown on the Drawings.
 4. Company switches shall operate on 120/208 VAC, 4 wire + ground, 60 Hz service as standard. 5 Wire + ground, 200% Neutral service shall be available as an option, and provided as noted herein and shown on the Drawings.
 5. Isolated ground connections shall be provided for company switches designated for audio/video power.
 6. All connections from the main breaker to the output panel shall be by copper bus. Aluminum buss shall not be acceptable.
 7. The fault current protection rating of the main breaker shall be 65,000 SCCR minimum.
 8. Company switch shall be hipot tested at 1250VAC for no less than 10 seconds.
 9. Company switch shall have a lockable, hinged connection chamber that contains both direct wire lugs and single pole Cam-Lok series E1016 connectors.
 10. The connection chamber door shall engage the shunt-trip mechanism of the main circuit breaker whenever it is not fully closed.
 11. Neutral and Ground Cam-Lok outlets shall be male connectors.

12. A locking mechanism shall be provided to allow a padlock or lockout tag to secure the breaker in the off position.
13. Replaceable indicator lamps shall be provided for each supply phase, labeled with NEC specified color codes and alphabetic names of phases.
14. Replaceable indicator lamp shall be provided for ground integrity.
15. A warning label specifying the proper sequence for connection and removal of cable connectors shall be permanently attached to the enclosure, as mandated by the NEC.

C. Identification Label

1. Provide signage on each company switch permanently attached to the equipment indicating the following:
 - a. Panel identification name and number
 - b. Feed type and size
 - c. Feed source
2. Character size shall be 1/4" high letters for equipment designations and 2 1/16" high letters for subsidiary information.

PART 3 – EXECUTION

3.1 PROTECTION OF EQUIPMENT

- A. Protect the equipment in this and Related Sections from damage and deterioration during all phases of the work, from the time of manufacture to the acceptance of the completed installation.

3.2 INSTALLATION

- A. Install company switches as located on the drawings. Installation shall be in accordance with manufacturer's written instructions, recognized industry practice, and applicable requirements of the National Electrical Code and other standards.
- B. Field terminations shall be through conduit to terminals on the main breaker.
- C. Wire nuts and field soldered connections, except where noted, shall not be acceptable.
- D. Equipment shall be grounded, as shown on drawings and in accordance with applicable codes and regulations and/or at the advice of the Manufacturer.

3.3 COMMISSIONING

- A. Prior to energization of the equipment, perform the following tests and inspections. Correct deficiencies and retest deficient items.
 1. Inspect each device for defects, finish failure, corrosion, physical damage, correct labeling, and nameplate.
 2. Perform operational tests on mechanical parts and operable devices according to manufacturer's instructions or routine functional operation.

3. Check tightness of electrical connections with torque wrench calibrated within the previous six (6) months using Manufacturer's recommended torque values.
4. Verify correct phase relationship and capacity.
5. Set calibration of overcurrent protection.
6. Measure / adjust the voltage at each phase output receptacle. Voltage requirements shall be determined by the Electrical Engineer.

3.4 DEMONSTRATION AND ACCEPTANCE

- A. The Architect and/or owner's representative shall witness a full demonstration of each feature of each piece of equipment in the system.
 1. Contractor shall provide all necessary personnel and equipment to demonstrate fully the system's compliance to the specifications.
 2. Contractor's project representative shall be present during testing as required.
 3. Full and uninterrupted access to all areas shall be provided as necessary to complete testing and demonstration.
- B. Subject to the on-site demonstration being satisfactory, the Architect and/or owner's representative shall accept the equipment on behalf of the Owner.
- C. Should the demonstration prove unsatisfactory, the Theatre Consultant and the Architect and/or owner's representative shall inform the Contractor in writing, and the Contractor shall rectify the problems. Problems should be rectified in the shortest time possible. During this period of remedial work, the Owner shall have beneficial use of the equipment. The Warranty period shall commence upon final acceptance by the Owner.

END OF SECTION

DIVISION 26 SECTION 26 29 13
MOTOR CONTROLLERS
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SECTION 26 29 13 - 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. This Section includes AC motor-control devices rated 600 V and less that are supplied as enclosed units.
- B. Related Sections include the following:
 - 1. Division 26 Section 260500, *Common Work Results for Electrical* for Mechanical - Electrical coordination requirements.
 - 2. Division 23 Section 230600, *Heating, Ventilating and Air Conditioning Equipment* for general-purpose, ac, adjustable-frequency, pulse-width-modulate controllers for use on variable torque loads in ranges up to 200 hp.

1.3 DEFINITIONS

- A. CPT: Control power transformer.
- B. N.C.: Normally closed.
- C. N.O.: Normally open.
- D. OCPD: Overcurrent protective device.

1.4 SUBMITTALS

- A. Product Data: For products specified in this Section. Include dimensions, ratings, and data on features and components.
- B. Test Reports: Indicate and interpret test results for compliance with performance requirements.
- C. 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.
- D. Qualification Data for Field Testing Agency: Certificates, signed by Contractor, certifying that agency complies with requirements specified in *Quality Assurance* Article below.

- E. Submit a schedule of equipment to indicate motor controller ratings, sizes, and other electrical characteristics for each item of equipment.
- F. Load Current and Overload Relay Heater List: Compiled and submitted by Contractor. Arrange to demonstrate selection of heaters to suit actual motor nameplate full load currents.
- G. Wiring Diagrams: For power, signal, and control wiring.
- H. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section 017823, *Operation and Maintenance Data*, include the following:
 - 1. Routine maintenance requirements for enclosed controllers and installed components.
 - 2. Manufacturer's written instructions for setting field-adjustable overload relays.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain, within 50 miles (80 km) of project site, a service center capable of providing training, parts, and emergency maintenance and repair.
- B. Field Testing Agency Qualifications: An independent testing agency with experience and capability to satisfactorily conduct testing indicated without delaying the Work. Evaluation criteria shall be according to ASTM E 699.
- C. Source Limitations: Obtain similar motor-control devices through one source from a single manufacturer.
- D. Comply with NFPA 70.
- E. Listing and Labeling: Provide motor controllers specified in this Section that are listed and labeled.
 - 1. The Terms *Listed* and *Labeled*: As defined in the National Electrical Code, Article 100.
 - 2. Listing and Labeling Agency Qualifications: A *Nationally Recognized Testing Laboratory* as defined in OSHA Regulation 1910.7.
- F. UL Compliance: UL 508, *Industrial Control Devices, Controllers and Assemblies*.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller.

1.7 PROJECT 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 (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 - 2. Altitude: Not exceeding 6600 feet (2010 m).

1.8 COORDINATION

- A. Coordinate features of controllers and accessory devices with pilot devices and control circuits to which they connect.
- B. Coordinate features, accessories, and functions of each motor controller with the rating and characteristics of the supply circuit, the motor, the required control sequence and the duty cycle of the motor and load.
- C. The horsepower rating of all starters shall be checked against actual motor to be controlled, before installation and correct size overload elements shall be provided for all starters based on nameplate and manufacturer's recommendation.
- D. Provide all control devices and wiring, where not provided under Division 23, required for all equipment.
- E. Motors and controllers shall be provided for voltage and current characteristics as indicated. In the event that equipment provided is of different electrical characteristics than the ones specified, any increase in electrical feeders, conduits, circuit breakers, etc., including increase of labor cost shall be the responsibility of the Contractor.
- F. Provide branch circuits for all motors to the starting equipment and then to the motors, complete with all control wiring for automatic and remote control where required or noted. Conduits to motors shall terminate at the conduit fittings on the motors, the final connection being made with Liquid-Tight Flexible Metal Conduit (LFMC), Seal-tight "UA", or approved equal.
- G. All conduits and wiring required for control work from the holding coil circuit of the starter, including the furnishing and installation of control devices such as auxiliary contacts, control relays, time delay relays, pilot lights, selector switches, alternators, etc., shall be provided and installed by other trades unless otherwise indicated.
- H. Power Branch Circuits: Wire sizes for branch circuits not specifically called for on drawings or specifications shall be based on 125 percent of the full load current of the motor unless the voltage drop of motor branch circuits exceeds 1-1/2 percent from the distribution panel to the motor; in which case, voltage drop shall govern wire sizes. A power factor of 80 percent shall be used for motors in such calculations.

1.9 EXTRA MATERIALS

- 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. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
 - 4. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following. No other manufacturers are acceptable.
 - 1. ABB-GE Electrification Equipment
 - 2. Eaton Corporation; Westinghouse & Cutler-Hammer Products.
 - 3. Siemens Energy and Automation, Inc.
 - 4. Allen-Bradley Company; Industrial Control Group.
 - 5. Crouse-Hinds ECM; Cooper Industries, Inc. Division
- B. All motor controllers shall be NEMA type controllers. IEC type controllers shall NOT be acceptable.

2.2 MANUAL MOTOR CONTROLLERS

- A. Description: NEMA ICS 2, AC general-purpose Class A manually-operated, full-voltage controller for fractional horsepower induction motors, with thermal overload unit. Manual motor controllers shall be equipped with red pilot light, hand-off-automatic selector switch and toggle operator. Provide size and number of poles as required for a complete installation of the equipment being connected.
- B. Thermal Overload Units:
 - 1. Thermal overload units shall be melting alloy type, properly sized for the equipment being protected, and shall be interchangeable. Controller shall be inoperable if thermal overload unit is removed.
- C. Enclosure: ANSI/NEMA ICS 6; Type 1 for interior use and Type 4X stainless steel or cast iron for damp or wet locations. Provide flush-mounted enclosures for units located in finished areas. Provide handle guard with locking provisions in the "off" position on all enclosures.
- D. Furnish Square D, Class 2510 Type F, or approved equal.

2.3 MANUAL MOTOR SWITCHES

- A. Description: NEMA ICS 2, AC general-purpose Class A manually-operated, full-voltage controller for fractional horsepower induction motors, without thermal overload unit. Manual motor switches shall be equipped with red pilot light and toggle operator. Provide size and number of poles as required for a complete installation of the equipment being connected.
- B. Enclosure: ANSI/NEMA ICS 6; Type 1 for interior use and Type 4X stainless steel or cast iron for damp or wet locations. Provide flush-mounted enclosures for units located in finished areas. Provide handle guard with locking provisions in the "off" position on all enclosures.
- C. Furnish Square D, Class 2510 Type K, or approved equal.

2.4 MAGNETIC MOTOR CONTROLLERS

- A. Description: NEMA ICS 2, AC general-purpose Class A full-voltage horsepower-rated, non-reversing, across-the-line magnetic controller for induction motors.
- B. Control Circuit: Coordinate with Automatic Temperature Control contractor; obtained from integral control power transformer.
- C. Coil: Encapsulated type.
- D. Poles: As indicated.
- E. Size: NEMA size 1, unless otherwise indicated.
- F. Contacts: Totally enclosed, double-break, silver-cadmium-oxide power contacts. Contact inspection and replacement shall be possible without disturbing line or load wiring.
- G. Wiring: Straight-through wiring with all terminals clearly marked.
- H. Overload Relay: NEMA ICS. Provide with sensors in each phase matched to nameplate full-load current of specific motor to which they connect, and with appropriate adjustment for motor duty cycle.
 - 1. Melting Alloy: One-piece thermal unit construction. Thermal units shall be interchangeable. Overload relay control circuit contact shall be replaceable. Thermal units shall be required for starter to operate.
 - 2. Reset: Provide normally closed (N.C.) auxiliary contact.
 - 3. Reset: Unit shall offer both manual reset and remote reset using an external module.
- I. Options and Features:
 - 1. Control Power Transformers: Include a control power transformer with adequate capacity to operate connected pilot light, indicating and control devices, plus 100 percent spare capacity. Provide fused secondary protection and bond un-fused leg of secondary to enclosure.

2. Auxiliary Contacts: Provide one normally open (N.O.) and one normally closed (N.C.) auxiliary contact in each starter in addition to the standard normally open (N.O.) sealing contact.
 3. Push-Buttons: Momentary push buttons with a factory-applied hasp arranged so a padlock can be used to lock the push-button in depressed position with control circuit open.
 4. Cover Mounted Indicating Lights: White "Power Available" and green "Running" LED type indicating lights. "Power Available" indicating light shall be connected at the load side of the fused secondary terminals of the control power transformer. "Running" indicating light shall be connected through one normally open (N.O.) auxiliary control contact. Indicating lights connected to the start button or across the load side of starters will not be acceptable. Indicating lights shall be equipped with individual legend plates supplied by the manufacturer.
 5. Pilot Device Contacts: NEMA ICS 2, Form "Z".
 6. Selector Switches: Rotary type, Hand-Off-Automatic (H-O-A) selector switch. All switch positions shall be maintained contact.
 7. Auxiliary Relays: Provide factory-installed phase failure and reverse phase relay.
- J. Enclosure: Enclosure: ANSI/NEMA ICS 6; Type 1 for interior use and Type 4 stainless steel for damp or wet locations.
- K. Furnish Square D, Class 8536 Type S, or approved equal.
- 2.5 COMBINATION MAGNETIC MOTOR CONTROLLER
- A. Description: Combine magnetic motor controller with either disconnect, circuit breaker or motor circuit protector disconnect (as indicated on the drawings) in common enclosure.
1. Magnetic Motor Controllers: NEMA ICS 2, AC general-purpose Class A full-voltage, non-reversing, across-the-line magnetic controller for induction motors rated in horsepower.
 2. Motor Circuit Protectors: NEMA AB 1 circuit breakers with integral instantaneous magnetic trip in each pole. Circuit breaker shall have a color-coded externally operated handle. Operating handle shall give positive visual indication of "on/off" with red and black color-coding.
- B. Control Circuit: Coordinate with Automatic Temperature Control Contractor; obtained from integral control power transformer.
- C. Coils: Encapsulated type.
- D. Connections: As indicated.
- E. Size: NEMA size 1, unless otherwise indicated.
- F. Contacts: Totally enclosed, double-break, silver-cadmium-oxide power contacts. Contact inspection and replacement shall be possible without disturbing line or load wiring.
- G. Wiring: Straight-through wiring with all terminals clearly marked.

- H. Overload Relay: NEMA ICS. Provide with sensors in each phase matched to nameplate full-load current of specific motor to which they connect, and with appropriate adjustment for motor duty cycle.
 - 1. Melting Alloy: One-piece thermal unit construction. Thermal units shall be interchangeable. Overload relay control circuit contact shall be replaceable. Thermal units shall be required for starter to operate.
 - 2. Outputs: Provide normally closed (N.C.) auxiliary contact.
 - 3. Reset: Unit shall offer both manual reset and remote reset using an external module.
- I. Options and Features:
 - 1. Control Power Transformers: Include a control power transformer with adequate capacity to operate connected pilot light, indicating and control devices, plus 100 percent spare capacity. Provide fused secondary protection and bond un-fused leg of secondary to enclosure.
 - 2. Auxiliary Contacts: Provide one normally open (N.O.) and one normally closed (N.C.) auxiliary contact in each starter in addition to the standard normally open (N.O.) sealing contact.
 - 3. Push-Buttons: Momentary push buttons with a factory-applied hasp arranged so a padlock can be used to lock the push-button in depressed position with control circuit open.
 - 4. Cover Mounted Indicating Lights: White "Power Available" and green "Running" LED type indicating lights. "Power Available" indicating light shall be connected at the load side of the fused secondary terminals of the control power transformer. "Running" indicating light shall be connected through one normally open (N.O.) auxiliary control contact. Indicating lights connected to the start button or across the load side of starters will not be acceptable. Indicating lights shall be equipped with individual legend plates supplied by the manufacturer.
 - 5. Pilot Device Contacts: NEMA ICS Form "Z".
 - 6. Selector Switches: Rotary type Hand Off-Automatic (H-O-A) selector switch. All switch positions shall be maintained contact.
 - 7. Auxiliary Relays: Provide factory-installed phase failure and reverse phase relay.
- J. Enclosure: Enclosure: ANSI/NEMA ICS 6; Type 1 for interior use and Type 4X stainless steel for damp or wet location.
- K. Furnish Square D, Class 8539 Type S, or approved equal.

2.6 ENCLOSURES

- A. Enclosures: All motor controllers shall be mounted in enclosures. Flush or surface-mounted cabinets as indicated. NEMA 250, *Enclosures for Electrical Equipment*, Type 1, unless otherwise indicated to meet environmental conditions at installed location.
 - 1. Outdoor Locations: NEMA 250, Type 3R.
 - 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4X.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Select features of each motor controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.
- B. Select horsepower rating of controllers to suit motor controlled.
- C. Use fractional-horsepower manual controllers for single-phase motors, unless otherwise indicated.
- D. Hand-Off-Automatic Selector Switches: In covers of manual and magnetic controllers of motors started and stopped by automatic controls or interlocks with other equipment.
- E. Provide heaters and fuses correlated with full load nameplate current of motors provided. Set overload devices to suit motor provided.

3.2 INSTALLATION

- A. Install independently mounted motor-control devices according to manufacturer's written instructions.
- B. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components, including the pretesting and adjustment of solid-state controllers.
- C. Location: Locate controllers within sight of motors controlled, unless otherwise indicated.
- D. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks conforming to Division 26 Section 26500, *Common Work Results for Electrical*.
- E. Install freestanding equipment on concrete housekeeping bases conforming to Division 03 Section 037000, *Cast-in-Place Concrete*.
- F. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary bracing or moving parts from enclosures and components.
- G. Install power factor correction capacitors. Connect to the line side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.
- H. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section 262813, *Fuses*.
- I. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

- J. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- K. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Identify motor-control components and control wiring according to Division 26 Section 260553, *Electrical Identification*.
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device

3.4 CONTROL WIRING INSTALLATION

- A. Install wiring between motor-control devices according to Division 26 Section 260519, *Low-Voltage Electrical Power Conductors and Cables*.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic control devices where available.
 - 1. Connect selector switches to bypass only those manual and automatic-control devices that have no safety functions when switched in manual-control position.
 - 2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 CONNECTIONS

- A. Tighten connectors, terminals, bus joints, and mountings. Tighten field-connected connectors and terminals, including screws and bolts, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 56B.

3.6 FIELD QUALITY CONTROL

- A. **Testing Agency:** Provide services of a qualified independent testing agency to perform specified testing.
- B. **Testing:** After installing motor controllers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. **Procedures:** Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameters.
 - 2. Remove and replace malfunctioning units with new units, and retest.

- C. Reports: Prepare written reports certified by testing organization of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made.
- D. Labeling: On satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.
- E. Schedule visual and mechanical inspections and electrical tests with at least one week's advance notification.
- F. Pretesting: On completing installation of the system, perform the following preparations for tests:
1. Make insulation resistance test of conducting parts of motor control components; and of connecting supply, feeder, and control circuits. For devices containing solid-state components, use test equipment and methods recommended by the manufacturer.
 2. Make continuity tests of circuits.
 3. Provide set of Contract Documents to test personnel. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in the original Contract Documents.
 4. Provide manufacturer's instructions for installation and testing of motor control devices to test personnel.
- G. Visual and mechanical inspection: Include the following inspections and related work.
1. Motor-Control Device Ratings and Settings. Verify that ratings and settings as installed are appropriate for final loads and final system arrangement and parameters. Recommend final protective-device ratings and settings where differences are found. Use accepted revised ratings or settings to make the final system adjustments. Prepare and submit the load current and overload relay heater list.
 2. Inspect for defects and physical damage, NRTL labeling, and nameplate compliance with current project drawings.
 3. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instructions.
 4. Check tightness of electrical connections of devices with calibrated torque wrench. Use Manufacturer's recommended torque values.
 5. Clean devices using Manufacturer's approved methods and materials.
 6. Verify proper fuse types and ratings in fusible devices.
- H. Electrical Tests: Perform the following in accordance with manufacturer's instructions:
1. Make insulation resistance test of motor control devices conducting parts to the extent permitted by the manufacturer's instructions. Insulation resistance less than 100 megohms is not acceptable.
 2. Use primary current injection to check performance characteristics of motor-circuit protectors and for overload relays of controllers for motors 15 horsepower and larger. Trip characteristics not within manufacturer's published time-current tolerances are not acceptable.
 3. Make adjustments for final settings of adjustable-trip devices.

4. Test auxiliary protective features such as loss of phase, phase unbalance and undervoltage to verify operation.
 5. Check for improper voltages at terminals in controllers that have external control wiring when controller disconnect is opened. Any voltage over 30V is unacceptable.
- I. Correct deficiencies and retest motor control devices. Verify by the system tests that specified requirements are met.

3.7 CLEANING

- A. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally, using methods and materials recommended by manufacturer.

3.8 DEMONSTRATION

- A. Training: Engage a factory-authorized service representative to demonstrate solid-state and variable-speed controllers and train Owner's maintenance personnel.
1. Conduct a minimum of four (4) hours of training in operation and maintenance as specified in Division 01 Section "Contract Closeout". Include training relating to equipment operation and maintenance procedures.
 2. Schedule training with at least seven (7) days advance notice.

END OF SECTION

DIVISION 26 SECTION 26 33 23
CENTRAL EMERGENCY BATTERY INVERTER SYSTEM
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SECTION 26 33 23 - CENTRAL EMERGENCY BATTERY-INVERTER SYSTEM

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. Scope: Extent of battery-inverter system work is indicated on the drawings, in schedules, and the requirements of this Section and other Division 26 sections.
- B. Types: Types of battery-inverter systems covered in this Section include a packaged combination storage battery, and charger, solid state inverter and transfer switch.

1.3. QUALITY ASSURANCE

- A. Conform to National Fire Protection Agency (NFPA) 70, "National Electrical Code," in general, and Article 700 in particular.
- B. Conform to NFPA 101, "Code for Safety to Life from Fire in Buildings and Structures," for electrical sources for emergency illumination and exit marking.
- C. Underwriters Laboratories, Inc. (UL): Provide battery, inverter, charger and associated equipment which meets UL 924 "Emergency Lighting and Power Equipment." Provide central emergency battery-inverter units which are UL listed and labeled.
- D. For unit battery, provide 5 years unconditional full warranty and 6 years pro-rata warranty, signed and delivered with the submittals.

1.4. SUBMITTALS

- A. Product Data: Submit manufacturer's data for items listed below.
 - 1. Overall central emergency battery-inverter unit.
 - 2. Battery.
 - 3. Inverter.
 - 4. Charger
 - 5. Rectifier.
- B. Shop Drawings: Submit dimensioned drawings of each unit. Show arrangement of front panel controls and indicators.

- C. Maintenance Data: Submit maintenance data and parts list. Include this data in operation and maintenance manual.

1.5. DELIVERY, STORAGE, AND HANDLING

- A. Handling: Handle units carefully to prevent damage, denting, and scoring. Do not install damaged units or components; replace with new.
- B. Storage: Store units in clean dry place. Protect from weather, dirt, and physical damage.

PART 2 - PRODUCTS

2.1. CENTRAL EMERGENCY BATTERY-INVERTER SYSTEM

- A. Basis-of-Design Product: Subject to compliance with requirement, provide Central Lite Trident LSN D Series, Model D-LSN-208-37-G-120/208-N-D-25-01 or comparable product by one of the following:
 - 1. DSPM (Digital Signal Process Manufactures)
 - 2. Power Sentry
 - 3. Myers Power Products
- B. Description: Provide integrated, packaged combination battery, charger, inverter, maintenance by-pass, protective devices and controls arranged to provide an emergency electrical supply source for alternating current loads. Duration of supply after failure of normal power shall be not less than 1.5 hours to 87.5 percent of battery voltage for full rated load. The UPS shall be designed to operate as an on-line, double conversion, reverse-transfer system in the following modes:
 - 1. Normal: The critical AC load is continuously supplied by the UPS inverter. The rectifier/charger derives power from a utility AC source and supplies DC power to the inverter while simultaneously float-charging a power reserve battery.
 - 2. Emergency: Upon failure of utility AC power, the critical AC load is supplied by the inverter, which without any switching, obtains power from the battery. There shall be no interruption of power to the critical load upon failure or restoration of the utility AC source.
 - 3. Recharge: Upon restoration of utility AC power, after a utility AC power outage, the rectifier/charger shall automatically restart, walk-in, and gradually assume the inverter and battery recharge loads.
 - 4. Construction: Units shall be modular, providing easy field replacement of components. Housing in National Electrical Manufacturers Association (NEMA) 1 steel cabinet with manufacturer's standard baked enamel finish over corrosion resistant primer treatment. Provide access to all components through hinged doors with flush tumbler lock and catch. Cooling of the UPS shall be by forced air. Low-velocity fans shall be used to minimize audible noise output. Fan power shall be provided by the UPS output. There shall be redundant fans. The thermal design, along with all thermal and ambient sensors, shall be coordinated with the protective devices before excessive component or internal cabinet temperatures are exceeded.
 - 5. Rating: Provide capacity and input and output voltage ratings as indicated on the drawings.

Provide capacity rating for 100 percent high power factor electronic and digital fluorescent lamp ballast load.

- a. Input to the UPS Unit shall be 280V, 1-phase, 3-wire.
- b. Output from the UPS inverter shall be 280/120V, 1-phase, 3-wire.

C. Rectifier/Charger: The term rectifier/charger shall denote the solid-state equipment and controls necessary to convert incoming AC power to regulated DC power for input to the inverter and for battery charging. The rectifier/charger shall be a solid-state type with constant voltage/current limiting control circuitry. The rectifier shall have the following features:

1. The rectifier/charger unit shall be provided with AC input current limiting whereby the maximum input current shall be limited to 125% of the full input current rating. The rectifier/charger shall operate at a reduced current limit mode whenever the critical load is powered from the UPS static bypass circuit such that the maximum UPS input current will not exceed 125% of full load input current. In addition, the rectifier/charger shall have a battery current limit, adjustable from 0 to 25% of the full load input current.
2. The rectifier/charger shall contain a timed walk-in circuit that causes the unit to gradually assume the load over a 20-second time interval after input voltage is applied. Walk-in time shall be field selectable for 5 through 20 seconds.
3. The rectifier/charger shall have a filter to minimize ripple voltage into the battery. Under no conditions shall ripple voltage into the battery exceed 2% RMS. The filter shall be adequate to ensure that the DC output of the rectifier/charger will meet the input requirements of the inverter. The inverter shall be able to operate from the rectifier/charger with the battery disconnected.
4. Upon restoration of utility AC power, after a utility AC power outage and prior to a UPS automatic end-of-discharge shutdown, the rectifier/charger shall automatically restart, walk-in, and gradually assume the inverter and battery recharge loads.
5. In addition to supplying power for the inverter load, the rectifier/charger shall be capable of producing battery charging current sufficient to replace 95% of the battery discharge power within ten (10) times the discharge time. After the battery is recharged, the rectifier/charger shall maintain the battery at full charge until the next emergency operation.
6. There shall be DC over-voltage protection so that if the DC voltage rises to the pre-set limit, the UPS shall shut down automatically and initiate an uninterrupted load transfer to the static bypass line.

D. Inverter: The term inverter shall denote the solid-state equipment and controls to convert DC power from the rectifier/charger or battery to regulated AC power for supporting the critical load. The inverter shall use Insulated Gate Bipolar Transistors (IGBTs) in a phase-controlled, pulse width modulated (PWM) design capable of providing the specified AC output. The inverter shall have the following features:

1. The inverter shall be capable of supplying current and voltage for overloads exceeding 100%. The inverter is to provide 150% of full load for 1 minute and 125% of full load for 10 minutes. A status indicator and audible alarm shall indicate overload operation. The UPS shall transfer the load to bypass when overload capacity is exceeded.
2. The inverter shall be capable of supplying an overload current of 150% of its full-load rating for one minute. For greater currents or longer time duration, the inverter shall have electronic current-limiting protection to prevent damage to components. The critical load will be transferred to the static bypass automatically and uninterrupted. The inverter shall

- be self-protecting against any magnitude of connected output overload. Inverter control logic shall sense and disconnect the inverter from the critical AC load without the requirement to clear protective fuses.
3. The output voltage shall be maintained to within $\pm 5\%$ with a 0-to-100% step load change or a 100%-to-0 step load change. The output voltage shall recover to within 1% of nominal voltage within 1 cycle.
 4. For linear loads, the output voltage total harmonic distortion (THD) shall not be greater than 3%. The output rating is not to be derated in kVA nor kW due to the 100% nonlinear load.
 5. Electronic controls shall be provided to regulate each phase so that an unbalanced loading will not cause the output voltage to go outside the specified voltage unbalance or phase displacement.
 6. Power semiconductors in the inverter unit shall be fused with fast-acting fuses so that loss of any one power semiconductor will not cause cascading failures.
 7. For rapid removal of the inverter from the critical load, the inverter control electronics shall instantaneously turn off the inverter transistors. Simultaneously, the static transfer switch shall be turned on to maintain continuous power to the critical load.
 8. The inverter shall be protected by the following disconnect levels:
 - a. DC Overvoltage Shutdown
 - b. DC Undervoltage Warning (Low Battery Reserve), adjustable
 - c. DC Undervoltage Shutdown (End of Discharge)
 9. The inverter shall use a software control to adjust the output voltage from $\pm 5\%$ of the nominal value.
 10. The output frequency deviation, including short time fluctuations and drift, shall not exceed 0.1% from the rated frequency.
- E. Static Transfer Switch: A static transfer switch and bypass circuit shall be provided as an integral part of the UPS. The switch shall operate within one (1) second. The static switch shall be a naturally commutated high-speed static (SCR type) device rated to conduct full load current continuously. The switch shall have an overload rating to clear a 20-ampere load branch circuit breaker. The static transfer switch shall have the following features:
1. The static transfer switch control logic shall contain an automatic transfer control circuit that senses the status of the inverter logic signals, and operating and alarm conditions. This control circuit shall provide an uninterrupted transfer of the load to an alternate bypass source without exceeding the transient limits specified herein, when an overload or malfunction occurs within the UPS, or for bypassing the UPS for maintenance.
 2. The transfer control logic shall automatically turn on the static transfer switch, transferring the critical AC load to the bypass source, after the transfer logic senses any of the following conditions:
 - a. Inverter overload capacity exceeded
 - b. Critical AC load overvoltage or undervoltage
 - c. Battery protection period expired
 - d. UPS fault condition
 3. The transfer control logic shall inhibit an automatic transfer of the critical load to the bypass source if any of the following conditions are present:

- a. Inverter/bypass voltage difference exceeding preset limits
 - b. Bypass frequency out of limits
 - c. Bypass out-of-synchronization range with inverter output
4. Retransfer of the critical AC load from the bypass source to the inverter output shall be automatically initiated unless inhibited by manual control. The transfer control logic shall inhibit an automatic retransfer of the critical load to the inverter if one of the following conditions exists:
- a. Bypass out of synchronization range with inverter output
 - b. Inverter/bypass voltage difference exceeding preset limits
 - c. Overload condition exists in excess of inverter full load rating
 - d. UPS fault condition present
- F. **Battery Power Pack:** The battery power pack shall include sealed, lead-acid valve regulated battery cells housed in a separate cabinet(s) that matches the UPS cabinet styling to form an integral system line-up. Battery cells shall be mounted on slide-out trays for ease of maintenance. A battery disconnect circuit breaker shall be included for isolation of the battery pack from the UPS module. The UPS shall automatically be disconnected from the battery when the battery reaches the minimum discharge voltage level. Casters and leveling feet shall also be provided with the battery power pack cabinet for ease of installation.
- G. **Metering:** The following parameters shall be displayed:
1. Input AC voltage line-to-line.
 2. Input AC current for each phase
 3. Input frequency
 4. Battery voltage
 5. Battery charge/discharge current
 6. Output AC voltage line-to-line and line-to-neutral for each phase
 7. Output AC current for each phase
 8. Output frequency
 9. Percent of rated load being supplied by the UPS
 10. Battery time left during battery operation
- H. **Alarm Messages:** The following alarm messages shall be displayed:
1. Input power out of tolerance.
 2. Input phase rotation incorrect
 3. Incorrect input frequency
 4. Charger in reduced current mode
 5. Battery charger problem
 6. Battery self test
 7. Low battery warning (adjustable 1 to 99 minutes)
 8. Low battery shutdown
 9. DC bus overvoltage
 10. Bypass frequency out of range
 11. Load transferred to bypass
 12. Excessive retransfers attempted
 13. Static switch failure
 14. UPS output not synchronized to bypass power
 15. Input power single phased

16. Input voltage sensor failed
17. Inverter leg overcurrent in X-phase
18. Output undervoltage
19. Output overvoltage
20. Output overcurrent
21. System output overloaded
22. Load transferred to bypass due to overload
23. Overload shutdown
24. Control error
25. Critical power supply failure
26. Load transferred due to internal protection
27. External shutdown (remote EPO activated)
28. Fan failure
29. Overtemperature shutdown impending
30. Overtemperature shutdown
31. An audible alarm shall be provided and activated by any of the above alarm conditions.

I. Status Messages:

1. Normal operation
2. Load on UPS
3. Load on static bypass
4. System shutdown
5. UPS on battery

J. Remote Status Panel: A remote status panel shall be NEMA Type 1 enclosure for wall mounting. The remote panel shall include the following:

1. Load on UPS LED
2. Load On Bypass LED
3. Battery Discharge LED
4. Low Battery Reserve LED
5. UPS Alarm Condition LED
6. New Alarm Condition LED (for a second UPS alarm condition)
7. Audible Alarm with Reset pushbutton
8. Lamp Test/Reset pushbutton

K. Instructions: Provide complete printed instructions, including parts list and complete wiring diagram in a pocket inside of front door.

PART 3 - EXECUTION

3.1. INSTALLATION

- A. Housekeeping Pad: For floor-mounted units, provide a 4-inch high concrete housekeeping pad. Plan dimensions 3-inch greater than those of unit.
- B. Manufacturer's Instruction: Install and connect in accordance with detailed instructions furnished by manufacturer.

- C. Cleaning: Clean the unit of dirt and splatter upon completion of installation.
- D. Clearance: Provide minimum 36-inch clearance in front of unit as well as additional side and rear clearance if required by manufacturer.

3.2. START-UP, TEST AND ADJUSTMENT

- A. Factory Technician: Provide the services of a factory trained technician to assist on-site in start-up, testing and adjustment of the unit and in training of maintenance personnel.
- B. System Check: Under supervision of factory technician, check all system functions and operations and adjust to assure operation is in accordance with specifications.
- C. Test: Upon completion of installation of system and after building circuits have been energized from normal power source, test system to demonstrate operation under emergency conditions.
 - 1. Test to demonstrate all functions and protective operations of the system.
 - 2. Simulate malfunctions to verify proper protective device functioning.
 - 3. Provide instruments as required to make positive observation of test results.
 - 4. Include the following in tests:
 - a. Duration of supply on "emergency."
 - b. Low battery voltage shut down.
 - c. Normal transfer to battery source and retransfer to normal.

- 3.3 MAINTENANCE CONTRACTS: A complete offering of preventive and full service maintenance contracts for both the UPS system and battery system shall be available. Maintenance contract shall be based on 2-year integrals. An extended warranty and preventive maintenance package shall be available. Warranty and preventive maintenance service shall be performed by factory-trained service personnel.

END OF SECTION

DIVISION 26 SECTION 26 36 00
TRANSFER SWITCHES
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SECTION 26 36 00 – TRANSFER SWITCHES

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 transfer switches rated 600 V and less, including the following:
 1. Automatic transfer switches.
 2. Manual transfer switches.
 3. Remote annunciation systems.

1.3 ACTION SUBMITTALS

- A. Product Data: Include ratings and dimensioned plan, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, electrical connections, electrical ratings, interlocking methods, and material lists for switch specified.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
 1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and loads and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

1.4 INFORMATION SUBMITTALS

- A. Qualification Data: For manufacturer and testing agency.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section 017800, *Operation and Maintenance Data*, include the following:
 1. Features and operating sequences, both automatic and manual.

2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 QUALITY ASSURANCE

- A. **Manufacturer Qualifications:** Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- B. **Testing Agency Qualifications:** An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- C. **Testing Agency's Field Supervisor:** Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- D. **Source Limitations:** Obtain automatic transfer switches, bypass/isolation switches, and remote annunciators through one source from a single manufacturer.
- E. **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. Comply with NEMA ICS 1.
- G. Comply with NFPA 70.
- H. Comply with NFPA 110.
- I. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.7 WARRANTY

- A. Transfer switches shall be under warranty for a period of five years after the date of acceptance. The Contractor shall submit satisfactory warranty documents.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. **Transfer Switches:**
 1. **Basis-of-Design Product:** Subject to compliance with requirements, provide Emerson; ASCO Power Technologies, LP or comparable product by one of the following:
 - a. ABB-GE Electrification Equipment

- b. Russelectric, Inc.

2.2 GENERAL TRANSFER SWITCHES

2.3 SFER-SWITCH PRODUCT REQUIREMENTS

- A. 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.
- B. Tested Fault-Current Closing and Withstand 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.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplish by a nonfrictionally momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. 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 not acceptable.
 - 2. Switch Action: Double throw; mechanically held in both directions.
 - 3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.
- H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- I. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
- J. Battery Charger: For generator starting batteries.
 - 1. Float type rated 10A.
 - 2. Ammeter to display charging current.

3. Fused ac inputs and dc outputs.
- K. 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.
- L. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section 260553, *Electrical Identification*.
 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.
- M. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and IUL 508, unless otherwise indicated.

2.4 AUTOMATIC TRANSFER SWITCHES

- A. Comply with Level 1 equipment according to NFPA 716.
- B. Switching Arrangement: Double-throw type, incapable of stopping or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Manual Switch Operation: 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.
- D. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- E. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.
- F. Automatic Transfer Switch Features:
 1. Under-voltage Sensing for Each Phase of Normal 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 is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.

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 0 to 30 minutes, and factory set for 10 minutes to 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. Automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
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: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shut down 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 1 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - a. Exercise 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 not available.

2.5 NONAUTOMATIC TRANSFER SWITCHES

- A. Electrically Operated: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
- B. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.
- C. Pilot Lights: Indicate source to which load is connected.

- D. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and alternative-source sensing circuits.
 - 1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - 2. Emergency Power Supervision: Red light with nameplate engraved "Alternative Source Available."
- E. Unassigned Auxiliary Contacts: Switch shall have one set of normally closed contacts for each switch position, rated 10 A at 240-V ac.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - 1. Switch Action: Double throw; mechanically held in both directions.
 - 2. Contacts: Silver composition or silver alloy for load-current switching.
 - 3. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 4. Material: Hard-drawn copper, 98 percent conductivity.
 - 5. Main and Neutral Lugs: Compression type.
 - 6. Ground bar.
 - 7. Connectors shall be marked for conductor size and type according to UL 1008.

2.6 CONTROL WIRING MONITORING

- A. Provide ASCO 5101 Engine Start Modules, or approved equivalent for monitoring of engine start circuit integrity from each ATS to generator including Fire Pump ATS furnished under Division 23. Provide a 5101-ATS Engine Start Module for each ATS and a single 5101-GEN Engine Start Module capable of monitoring eight (8) ATS's at the generator. Modules shall utilize standard engine control wiring. All modules shall be compatible with and wire into any contact-based engine start signal.
- B. Provide visual and audible annunciation of circuit faults at ATS remote annunciator and at generator.
- C. Automatically start generator when fault occurs on control wiring circuit(s).

2.7 REMOTE ANNUNCIATOR SYSTEM

- A. Functional Description: Remote annunciator panel shall annunciate conditions for each transfer switch. Annunciation shall include the following:
 - 1. Source available, as defined by actual pickup and dropout settings of transfer-switch controls.
 - 2. Switch position.
 - 3. Switch in test mode.
 - 4. Failure of communication link.
- B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

1. Indicating Lights: Grouped for each transfer switch monitored.
2. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
4. Lamp Test: Push-to-test or lamp-test switch on front panel.

2.8 SOURCE QUALITY CONTROL

- A. Factory test and inspect components, assembled switches, and associated equipment. 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.

PART 3. EXECUTION

3.1 INSTALLATION

- A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section 260548, *Seismic Controls for Electrical Systems*.
- B. Floor-Mounting Switch: Anchor to floor by bolting.
 1. Concrete Bases: 4 inches (100 mm) high reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section 260529, *Hangers and Supports for Electrical Systems*.
- C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- D. Identify components according to Division 26 Section 260553, *Electrical Identification*.
- E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches, including Fire Pump Controller/ATS. Consult with another Division, as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner, if necessary, to accommodate required wiring.
- B. Ground equipment according to Division 26 Section 260526, *Grounding and Bonding for Electrical Systems*.
- C. Connect wiring according to Division 26 Section 260519, *Low-Voltage Electrical Power Conductors and Cables*.

3.3 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. Testing Agency's Tests and Inspections:
1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 3. 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 connections and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
 4. After energizing circuits, 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 of 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 milliohms and values for 1 pole deviating by more than 50 percent from other pole.
 - 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.
 5. 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. Remove and replace malfunctioning units and retest as specified above.
- F. Prepare test and inspection reports.

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 as specified below. Refer to Division 01 Section 018200, *Demonstration and Training*.
- B. Coordinate this training with that for generator equipment.

END OF SECTION

NOT FOR BID

DIVISION 26 SECTION 26 43 13
SURGE PROTECTIVE DEVICES
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END OF SECTION 5

NOT FOR BID

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. Description: This section describes the materials and installation requirements for stand-alone Surge Protective Devices (SPDs) for the protection of all AC electrical circuits from the effects of lightning induced currents, substation switching transients and internally generated transients resulting from inductive and/or capacitive load switching.

1.3 REFERENCES:

- A. ANSI/IEEE C62.41 - IEEE Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits.
- B. ANSI/IEEE C62.45 - IEEE Recommended Practice on Surge Suppressor Testing.
- C. FIPS Pub 94 (1983) - Guide on Electrical Power and ADP Installation.
- D. National Electrical Code - Article 285.
- E. National Fire Protection Association - NFPA-20, NFPA-70, NFPA-75, NFPA-78.
- F. NEMA LS-1 Low Voltage Surge Protection Devices.
- G. NEMA 250 - Enclosures for Electrical Equipment.
- H. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.
- I. UL 1283 - Electromagnetic Interference Filters.
- J. UL 1449, Third Edition - Surge Protective Devices.

1.4 SUBMITTALS

- A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model indicated. Indicate overcurrent protection requirements.
- B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

- C. Maintenance Data: For surge protective devices to include in the maintenance manuals specified in Division 01.
 - D. Warranties: Special warranties as specified in this Section.
 - E. The submittals shall include:
 - 1. UL 1449, Fourth Edition Listing documentation verifying:
 - a. Short Circuit Current Rating (SCCR)
 - b. Voltage Protection Ratings (VPRs) for all modes
 - c. Maximum Continuous Operating Voltage (MCOV) rating
 - d. I-nominal (I-n) rating
 - e. Type 1 Device listing
 - 2. VPR, MCOV, I-n and Type 1 information is posted at www.UL.com, under Certifications. SCCR's are posted in manufacturer's UL documents.
 - 3. UL Standard 1283 Listing, documentation.
 - 4. UL data and visual inspection take precedence over manufacturer's published documentation.
 - F. Submittals shall include shop drawings including the following:
 - 1. Manufacturer's installation instruction manual and line drawings detailing dimensions and weights of enclosure.
 - 2. Internal wiring diagram illustrating all modes of protection in each type of SPD required.
 - 3. Wiring diagram showing all field connections and manufacturer's recommended wire and circuit breaker sizes.
 - G. Upon request, an encapsulated but complete SPD shall be presented for visual inspection. MOV type & quantity shall reflect kA ratings on product data sheets, verification of diagnostic monitoring, thermal & overcurrent protection, etc.
- 1.5 QUALITY ASSURANCE
- A. Listing and Labeling: Provide electrically operated equipment specified in this Section that is listed and labeled.
 - 1. The Terms *Listed* and *Labeled*: As defined in the National Electrical Code, Article 100.
 - 2. Listing and Labeling Agency Qualifications: A *Nationally Recognized Testing Laboratory* as defined in OSHA Regulation 1910.7.
 - 3. Comply with NFPA-70.

1.6 WARRANTY

- A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the contract Documents and shall be in addition to, and run concurrent with, other warranties made under requirements of the Contract Documents.
- B. Special Warranty: A written warranty, executed by manufacturer, agreeing to repair or replace components of Surge Protective Devices that fail in materials or workmanship within the specified warranty period.
 - 1. Warranty Period: Five (5) years (minimum) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The following listed manufacturers provide units of acceptable quality. Verify that the proposed units meet the specified requirements.
 - 1. Advanced Protection Technologies, Inc.
 - 2. EFI Electronics Corporation.
 - 3. Liebert Corporation.
 - 4. Current Technology, Inc.
 - 5. LEA Dynatech, Inc.
 - 6. Square-D Co.

2.2 SURGE PROTECTIVE DEVICES

- A. SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR). Fuse ratings shall not be considered in lieu of demonstrated withstand testing of SPD, per NEC 285.6.
- B. SPD shall be UL labeled as Type 1 (verifiable at UL.com), intended for use without need for external or supplemental overcurrent controls. Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal over-temperature controls. SPDs relying upon external or supplementary installed safety disconnects do not meet the intent of this specification.
- C. SPD shall be UL labeled with 20kA I-nominal (I-n) (verifiable at UL.com) for compliance to UL 961 Lightning Protection Master Label and NFPA 780.
- D. Suppression components shall be heavy duty 'large block' MOVs, each exceeding 30mm diameter.

E. Minimum surge current capability (single pulse rated) per phase shall be:

Distribution Panelboards & MCC:	200kA
Branch Panelboards:	100kA

F. SPD shall provide surge current paths for all modes of protection: L-N, L-G, L-L and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.

G. UL 1449 Listed Voltage Protection Ratings (VPRs) shall not exceed the following:

<u>System Voltage</u>	<u>L-N</u>	<u>L-G</u>	<u>L-L</u>	<u>N-G</u>
208Y/120	700V	700V	1200V	700V
480Y/277	1200V	1200V	1800V	1200V

(Mode VPRs verifiable at UL.com. Numerically lower is allowed/preferred; old style Suppressed Voltage Ratings (SVRs) shall not be submitted, nor evaluated due to outdated less-strenuous testing)

H. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV):

<u>System Voltage</u>	<u>Allowable System Voltage Fluctuation (%)</u>	<u>MCOV</u>
208Y/120	25%	150V
480Y/277	15%	320V

I. SPD shall include a serviceable, replaceable module (excluding Branch).

J. SPD shall have UL 1283 EMI/RFI filtering with a minimum attenuation of -50dB at 100kHz.

K. SPD shall include visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED. SPD shall include an audible alarm with on/off silence function and diagnostic test function (excluding branch).

L. SPD shall be provided with the following options:

1. One (1) set of NO/NC dry contacts
2. Surge event counter with back-up power source
3. Integral disconnect switch

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.
- C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice

and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

- D. Use crimped connectors and splices only. Wire nuts are unacceptable.
- E. 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 and UL 486B.

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
 - 2. Before energizing electrical circuitry, verify that the unit voltage and connection equipment voltage is the same.
 - 3. Inspect anchorage, alignment, grounding, and clearances.
 - 4. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.
- B. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION

DIVISION 26 SECTION 26 51 00
LIGHTING
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SECTION 26 51 00 - LIGHTING

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. Interior lighting fixtures, lamps, and drivers.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.
5. Exterior building mounted fixtures.

B. Related Sections:

1. Division 26 Section 260923, *Lighting Control Devices* for automatic control of lighting, including time switches, photoelectric relays, multipole lighting relays and contactors.
2. Division 26 Section 262726, *Wiring Devices* for snap switches and wall switches.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color-rendering index.
- C. LED: Light-emitting diode.
- D. LER: Luminaire efficiency rating.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting fixture, including ballast housing if provided.
- G. THD: Total harmonic distortion.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
1. Physical description of lighting fixture including dimensions.
 2. Emergency lighting units including battery and charger.
 3. Driver, THD, input power, input voltage, power factor, connector type, starting temperature.
 4. Energy-efficiency data.
 5. Life, output (delivered lumens) CCT, and CRI color rendition fidelity (Rf) and gamut (Rg) per IES TM-30.
 6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
 - a. Manufacturer Certified Data: Photometric data shall be certified by a 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 lighting fixtures. Include plans, elevations, sections, details, and attachments to other work.
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.
- C. Samples: For each lighting fixture indicated in the Interior Lighting Fixture Schedule. Each Sample shall include the following:
1. Lamps and ballasts, installed.
 2. Cords and plugs.
 3. Pendant support system.
- D. Installation instructions.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- B. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
- C. Field quality-control reports.
- D. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
 - 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

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. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 2. Plastic Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
 - 3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.
 - 4. LED Modules (light engine and driver): Furnish at least (1) of each type.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
- 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 NFPA 70.
- D. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

1.9 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.10 WARRANTY

- A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace compo

nents of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
 2. Warranty Period for Self-Powered Exit Sign Batteries: Seven years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six years.
- B. Special Warranty for Drivers: Manufacturer's standard form in which driver manufacturer agrees to repair or replace drivers that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Electronic Drivers: Ten years from date of Substantial Completion.
- C. Special Warranty for LED luminaires: Manufacturer's standard form, made out to owner and signed by lamp manufacturer agreeing to replace LED modules and drivers that fail in materials or workmanship, f.o.b. the nearest shipping point to Project site within specified warranty period indicated below.
1. Warranty Period: Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In Interior Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection.
1. Basis of Design Product: The design of each item of luminaire and its support is based on the first product named. Subject to compliance with requirements, provide either the named product or comparable product by one of the other manufacturers specified.

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 4 and NEMA LE 5A as applicable.
- C. Metal Parts: Free of burrs and sharp corners and edges.
- D. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.

- E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- F. Diffusers and Globes:
 - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
 - b. UV stabilized.
 - 2. Glass: Annealed crystal glass unless otherwise indicated.
- G. Factory-Applied Labels: Comply with UL 1598. Include recommended lamp and ballasts. Labels shall be located 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 and ballast characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. CCT and CRI for all luminaires.

2.3 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 - 1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
- C. Self-Luminous Signs: Use strontium oxide aluminate compound to store ambient light and release the stored energy when the light is removed. Provide with universal bracket for flush-ceiling, wall, or end-mounting.

2.4 EMERGENCY LIGHTING UNITS

- A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.
 - 1. Battery: Sealed, maintenance-free, nickel metal hydride type.
 - 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - 3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay

- disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
 7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.5 LED LUMINAIRES

- A. A LED luminaire consists of LED light engine and driver, heat-sink, fixture housing, and optic assembly where applicable.
1. Temperature: Minimum starting temperature of -30 deg C (-22 deg F), minimum 40 deg C (104 deg F) ambient temperature rating.
 2. Life and Lumen Maintenance: Plus 50,000 hours rated life at greater than 70% lumen maintenance.
 3. CRI and CCT: 3500 deg K (+/- 275 K) CCT and greater than 80 CRI.
 4. Transient Voltage Protection: Rated to withstand 2.5 kV of transient line surge.
 5. Photometric Data and Test Reports: Comply with IESNA LM-79-08, IESNA LM-80-08, and ANSI C78.377-08.
 6. Radio Frequency Interference: Comply with FCC Part 15 Communications (Control of Interference) Regulations.
 7. Luminaires and components thereof shall comply with UL 8750 Standard of Safety.
 8. Five-year warranty on luminaire including LED light engine and driver.
 9. Power Factor: 90 percent minimum.
 10. Total Harmonic Distortion Rating: Less than 20 percent.
 11. RoHS compliant.
 12. Sound Rating: Class A.
 13. Overload, short circuit, and thermal protection.
 14. LED luminaire must be listed with the Design Lights Consortium or Energy Star Qualified Product list.
 15. Comply with UL 1591-08 NMX-J-307/1-ANCE/C22.2 NO.250.0-08, *Luminaires, LEDs*.

2.6 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 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 (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage (2.68 mm).
- F. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 GENERAL:

- A. Comply with NECA/IESNA 500-2006 "Standard for Installing Indoor Commercial Lighting systems" for all interior fixtures.
- B. Comply with NECA/IESNA 501-2006 "Standard for Installing Exterior Lighting Systems" for all exterior fixtures.

3.2 INSTALLATION

- A. Lighting fixtures:
 - 1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
 - 2. Install lamps in each luminaire.
- B. Temporary Lighting: If it is necessary and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.
- C. Remote Mounting of Drivers: Distance between the driver and fixture shall not exceed that recommended by driver manufacturer. Verify, with driver manufacturers, maximum distance between driver and luminaire.
- D. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.
 - 1. Install ceiling Solid #12AWG safety wires, independent of the ceiling suspension device, for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.
 - 2. Safety Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 - 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
 - 4. Install at least one independent support wire from structure to a tab on lighting fixture. Wire shall have breaking strength of the weight of fixture at a safety factor of 3.

E. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.

F. Connect wiring according to Division 26 Section 260519, *Low-Voltage Electrical Power Conductors and Cables*.

3.3 IDENTIFICATION

- A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Division 26 Section 260553, *Electrical Identification*.

3.4 FIELD QUALITY CONTROL

- A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
- B. Verify that self-luminous exit signs are installed according to their listing and the requirements in NFPA 101.
- C. 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.

3.5 STARTUP SERVICE

- A. Burn-in all LEDs that require specific aging period to operate properly, prior to occupancy by Owner.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
1. Adjust aimable luminaires in the presence of Architect.

END OF SECTION

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SECTION 26 60 10 – RIGGING SYSTEMS ELECTRICAL WORK

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. The work of this Section includes all labor, materials, equipment, and services necessary to complete the Stage Rigging and Draperies installation, as shown on the drawings and specified herein, including, but not limited to, the following:
 - 1. Motorized hoist
 - 2. Control system for motorized hoist
- B. The Contractors for the above work will furnish the control system components. The Electrical Contractor shall install the system components, provide conduit and wire runs between components, and perform all terminations.
- C. Electrical service for the above work is shown on the TR-series drawings.
- D. The TR-series Contract Drawings provide block diagrams and equipment locations. The final design of the control systems is the responsibility of the respective Contractors, who will supervise the Electrical Contractor's work.

1.3 PRACTICES AND PROCEDURE

- A. Practices and procedures for the work in this Section shall conform to applicable Sections in this Division.

END OF SECTION

SECTION 27 05 00 - TELECOMMUNICATIONS PATHWAYS AND SPACES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Telecommunications Room Build out
- B. Pathways for Telecommunications Systems
- C. Grounding and Bonding for Telecommunications

1.2 REFERENCES

- A. Industry Codes, Standards and Methods shall be observed, including the following.
 - 1. ANSI/TIA-568-1-E: Commercial Building Telecommunications Cabling
 - 2. ANSI/TIA-568-2-D: Balanced Twisted Pair Cabling and Component
 - 3. ANSI/TIA-568-3-D: Optical Fiber Cabling Components
 - 4. ANSI/TIA-569-E: Telecommunications Pathways and Spaces
 - 5. ANSI/TIA-570-B: Residential Telecommunications Cabling Standard
 - 6. ANSI/TIA-606-A: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
 - 7. ANSI/TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
 - 8. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Cabling Standard
 - 9. BICSI Telecommunications Distribution Method Manual (TDMM), Latest Edition
 - 10. National Fire Protection Agency (NFPA 70) National Electrical Code (NEC)
- B. Comply with all local, state and federal codes for telecommunications installations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements

- 1. All systems and equipment must comply with the Delaware State-Wide Information Technology and Architecture Standards, Latest Version.
- 2. Contractor shall outfit all telecom rooms according to T Drawings. Racks and other termination and distribution fields shall be installed according to manufacturer's guidelines and industry standards.
- 3. TR and TER layouts shall be approved by school Technology personnel prior to installation of cabling, pathways or termination hardware.

B. Performance Requirements

- 1. All equipment and equipment will be installed in an orderly and precise manner. Clearances between equipment will prevent incidental damage or unsafe conditions.
- 2. Equipment shall provide proper support and housing of all intended active and non-active components.
- 3. Refer to Telecom Room Details for precise location of equipment and termination fields.

1.4 SUBMITTALS

A. Product Data

1. Provide product data for all equipment listed in Part 2
2. Equipment data must be submitted in a single package and clearly indicated for efficient review. (by specifications section) Equipment submittals not clearly called out will be rejected without question at the contractor's expense for resubmittal.
3. Product data must be approved by designer and owner prior to purchase and installation of equipment.

B. Shop Drawings

1. Provide scaled drawings to show proposed equipment locations, clearances and administrative labeling of Telecom Rooms and equipment. All fields, racks and cabinets shall be methodically documented and permanently labeled agreed upon by school district.
2. Shop drawings must be approved by the designer and owner prior to purchase and installation of any equipment.

C. As-Built Drawings

1. Contractor shall upon completion of the project, provide a complete set of As-Built drawings. These drawings shall identify room numbers and outlet identification numbers for all low voltage cabling systems. Drawings should also include all IDF and MDF locations with a detailed layout of all racks, patch panels, trays, and wall fields.
2. Additional project information shall include Reline Details of all horizontal and backbone cable routes and pathways.
3. As-Built drawings shall be submitted in electronic CAD format and in hard copy at the end of the project.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements

1. All equipment shall be installed in a neat and professional manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the school district. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Substitutions

1. Conditions for consideration of "Or Equal" Products: Where products are specified by name and accompanied by the term "or equal", the proposed "or equal" product will be considered when the following conditions are satisfied.
 - a. If all the following conditions are not satisfied, Design Consultant will return requests without action, except to record noncompliance with these requirements
 - b. Proposed product does not require extensive revisions to the Contract Documents.
 - c. With the exception of the product name or number and manufacturer's name, proposed product conforms with requirements indicated on the Drawings and in the Specifications in every respect and will produce indicated results.
 - d. Proposed product is fully documented and properly submitted.
 - e. Proposed product has received necessary approvals of authorities having jurisdiction.
 - f. Proposed product is compatible with and has been coordinated with other portions of the Work.

- g. Proposed product provides specified warranty.
2. If proposed product involves more than one contractor, proposed product has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
3. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
4. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.
5. Submission is accompanied with proposed product's Manufacturer signed written statement on Manufacturer's letterhead, certifying that manufacturer complies with requirements in the Contract Documents.

1.6 WARRANTY

- A. Warranty: Installer must provide manufacturer's warranty without cost to the owner during that time period, including materials, hourly costs, etc.,.
- B. Installer's warranty shall guarantee workmanship for a period of one year, during which time any deficiency in installation shall be repaired or replaced at no additional cost to the school district. Contractor must respond within 2 business days of written notification.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Distribution Racks and Cabinets

1. Floor Mounted Free Standing 2 Post Racks
 - a. Hubbell HPW84RR19E 48" / 95" X 6" Equipment Rack with
 - i. Hubbell HC219CE3N 2U Horizontal Manager
 - ii. Hubbell XS1010 Vertical Cable Manager
 - b. Or approved equivalent from Cooper B-Line, Ortronics, Systimax or Leviton.
2. Floor Mounted Free Standing 4 Post Racks
 - a. Four post aluminum frame with EIA rails
 - b. 45 Rack Units
 - c. Black
 - d. Similar to Ortronics OR-QC422442 or approved equivalent.
3. Floor Mounted Equipment Cabinet
 - a. The cabinet frame shall be constructed of four cold rolled steel components – top, bottom, left and right welded to form a self-supporting framework. The side members shall be fabricated from 16ga cold rolled steel. The top and bottom shall be fabricated from 14ga cold rolled steel. The vertical uprights shall have integral cable management channels with provisions for hook and loop or traditional cable ties. The frame shall be bolted to the floor, and side by side to other frames.

- b. The side covers shall be constructed of 19ga cold rolled steel with double bent flanges along the entire perimeter. The side covers shall lift off easily via grip handles assembled to the covers. The side cover shall have clusters of rectangular perforation to accommodate ventilation for equipment providing greater than 100 sq. in. of ventilation.
 - c. The front door shall be a window door assembled to the frame via spring-loaded hinges at the top and bottom. The door shall be locking with a unique operator's key. The operator's key shall operate the front door only. The latch shall be flush to the door. The window shall be a .125" acrylic panel secured to a reinforced steel frame.
 - d. The rear door shall be a steel door assembled to the frame via spring-loaded hinges at the top and bottom. The door shall be locking with a unique service personnel key. The service personnel key shall operate both the rear and front doors. The latch shall be push button operated. The rear door shall be reinforced and have a cluster of rectangular perforations for ventilation.
 - e. The top shall have a removable panel in the center, designed to be replaced with a cooling fan, and six 3" diameter cable entry knockouts; three along each side to route cables directly into vertical cable organizers minimizing the number of bends to the cables.
 - f. The bottom panel shall be similarly configured with 6 knockout locations. The cabinet bottom shall also be provided with holes for securing the cabinet to the floor.
 - g. The top cover shall accept the mounting of a 250 CFM cooling fan.
 - h. The cabinet shall be pre-configured for 19" mounting with universal hole spacing per EIA 310 D. The cabinet shall feature three sets of rails, front, center, and rear. The front set of rails shall be 20 rack positions high, from the bottom of the cabinet. The rear and center rails shall be the full internal height. The recess of all three sets of rails shall be adjustable forward and back. The rails shall be tapped for a #10-32 screw. The center rails shall be formed in a 'C' profile, 3" deep, tapped on both the front and rear flanges so as to provide the functionality of an open frame rack. The front and rear rails shall be an L shape.
 - i. The entire enclosure shall be finished with a durable polyurethane powder coat – medium texture and shall be available in black.
4. All racks and cabinets shall be capable of supporting the weight and space of existing and proposed equipment. 20% growth capacity shall be provided in addition to detailed requirements.
 5. Racks, cabinets, and other termination equipment shall be properly secured to floor with appropriate anchors and bonded to Telecommunications Grounding System.
 6. Unit shall be similar to Comenics OR-DCC422846-00002 or approved equivalent.
 7. Provide (1) 8-port transient surge protection strip for each TR and per rack/cabinet in the TR and TRs.
- B. Cable Management
1. Horizontal Cable Management
 - a. Horizontal wire management panels are required for patch panels in certain racks. (See drawings for rack diagrams.)
 - b. Horizontal cable management shall occupy 1 or 2 rack units, as shown on T Drawings.
 - c. Similar to OR-MM6HMF1RU or approved equivalent
 2. Vertical Cable Management

- a. Vertical Cable management shall be provided for all racks. Provide 2 for each rack or cabinet.
 - b. Cable management shall be – Ortronics OR-60400510, or approved equivalent.
- C. Wiremesh Cable Tray
1. Cablofil CF 54/3300
 2. Cablofil CF 105/300
- D. Ladder-Type Aluminum Cable Tray (Ladder Rack)
1. All TR and TER locations shall receive ladder-rack style cable tray as shown in T-series drawings for cable distribution.
 2. Class 5160 or Chatsworth “TELCO-Style Cable Runway,” 12-inch ladder rack from racks/cabinets from corridor or other wire routing space where indicated on drawings.
- E. Conduit
1. In-wall conduit shall be provided for work in new areas. Refer to T Drawings for conduit details.
 2. Conduit bend radii shall follow current ANSI/TIA standards for telecommunications.
 3. Refer to T drawings for locations and sizes of all sleeves for telecommunications.
- F. Gang Boxes
1. In-wall Gangable Gang Boxes for low voltage.
 - a. Hubbell HBL985 Two Gang Box
 - b. Hubbell HBL986 Three Gang Box
 - c. Hubbell HBL989 Low Voltage Partition
 - d. Or approved equal
- G. Surface Mounted Raceway (SMR)
1. Surface mounted split channel raceway for power and data - Wiremold 4000
 - a. Coordinate all Wiremold for telecom equipment with electrical installer.
 - b. Provide associated colored connectors (see 271000) and faceplates per manufacturer’s recommendations for telecommunications.
 - c. Coordinate color and finish with architect prior to installation
- H. Floor Boxes and Poke-through Device
1. Small Capacity In-floor box
 - a. Coordinate all floor boxes and poke-through devices for telecom equipment with electrical installer.
 - b. Floor box shall meet latest UL standards for scrub water resistance
 - c. Four-Compartment Combination Box similar to Wiremold RBF4 or Wiremold RFB6
 - d. Top of box shall allow for matching floor finish insert and be constructed of metal
 - e. Provide all brackets and accessories for proper telecommunications installation.
 2. Large Capacity In-floor box

- a. Wiremold Evolution Series EFB6S with flush mounted cover.
3. Poke through
 - a. Unit shall be similar to Wiremold Evolution Series with 5 gangs.
- I. Distribution Backboard
 1. Plywood
 - a. $\frac{3}{4}$ " AC-grade plywood shall be provided as shown on T drawing details to line the walls within the TR. The plywood should be provided in 4' x 8' sheets.
 - b. Plywood shall be void free and painted on all sides with two coats of fire-resistant paint.
- J. Electrical Protection for Telecommunications
 1. Telecommunications Primary Bonding Busbar (PBB) and Telecommunications Secondary Bonding Busbar (SBB)
 - a. Provide one PBB in the Telecommunications Equipment Room as shown on T Drawings.
 - b. Provide a SBB in every Telecommunications Room and distribution cabinet location as shown on T Drawings.
 - c. The telecom grounding and bonding system shall be bonded to the main electrical ground for the facility.
- K. UPS Equipment
 1. Tripplite SMART3000RM2UN
 2. Tripplite SU2200RTXLCDN
- L. Rack mounted power strip
 1. Provide 10 port transient, surge protection strip (UL Listed) for each rack or cabinet.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Site Verification of Conditions

1. Contractor shall ensure that sufficient space has been allocated for the installation of all equipment per T Drawings prior to Installation. Clearances and existing equipment should be taken into consideration. If insufficient space exists, the Design consultant should be notified in writing before proceeding with Installation.

3.2 INSTALLATION

A. Distribution racks and Cabinets

1. Racks shall be assembled such that mounting rails are exactly perpendicular to the base.
2. Racks shall be secured to the floor using appropriate anchors.
3. Racks shall be grounded to the SBB or appropriate building ground using a minimum #6 grounding wire.

B. Distribution Backboard

1. Securely fasten backboard to wall-framing members to ensure it can support attached equipment.
2. Mount plywood on all available areas where telecommunications equipment may be located.
3. Refer to T Drawings for minimum coverage.

C. Ladder Rack and Cable Tray

1. Ladder rack and cable tray shall be properly secured using manufacturer recommended anchors and connectors.
2. Ladder rack and cable tray shall be routed according to T Drawing floor plans.
3. Ladder rack and cable tray shall be bonded to ground according to ANSI/TIA 607.

D. Firestop

1. Provide re-enterable, non-hardening, intumescent putty, rated for floors or wall, UL approved assembly, with approved packing material for fire stopping inside building cable penetrations thru conduits sleeves.
2. The material used for sealing all openings shall have a fire rating equal to or greater than the floor ceiling, wall or partition material.

E. Sleeves and openings

1. The telecommunications contractor shall provide sleeves through all walls and floors to protect cabling and or raceways installed as part of the telecommunications system. All sleeves shall extend through the respective wall or partition and finish with a connector protective bushing.
2. Sleeves through all fire rated structures shall have appropriate fire stop system.

END OF SECTION

SECTION 27 10 00 - STRUCTURED CABLING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Local Area Network (LAN) Cabling
- B. Telephone Cabling
- C. Termination Equipment for Telecommunications
- D. Faceplates and Outlets
- E. Classroom / Conference / Collaboration A/V Cabling

1.2 DEFINITIONS

- A. "Backbone Cabling" refers to telecommunications cabling that provides interconnections between telecommunications rooms, equipment rooms, and entrance facilities.
- B. "Communications Network Outlet (CNO)" refers to a collection of one or more mechanical cable termination device for horizontal cable in the work area.
- C. "Drop" refers to the vertical transition to a location of one or more CNOs.
- D. "Horizontal Cabling" refers to the cabling between and including the work area communications network outlet and the horizontal cross-connection in the telecommunications room.
- E. "Jack" refers to a female-style telecommunication receptacle.
- F. "Telecom Room (TR)" refers to an enclosed space for housing telecommunications equipment, cable terminations, and cross-connections. It is the recognized cross-connect between the backbone or trunk cabling and horizontal cabling.
- G. "Telecom Equipment Room (TER)" refers to a centralized space for telecommunications equipment that serves the occupants of the building, usually containing the headend equipment for the distribution system found in the building.

1.3 REFERENCES

- A. Industry Codes, Standards and Methods shall be observed, including the following:
 - 1. ANSI/TIA-569-1-E: Commercial Building Telecommunications Cabling
 - 2. ANSI/TIA-568-2-D: Balanced Twisted Pair Cabling and Components
 - 3. ANSI/TIA-568-3-D: Optical Fiber Cabling Components
 - 4. ANSI/TIA-569-E: Telecommunications Pathways and Spaces
 - 5. ANSI/TIA-570-B: Residential Telecommunications Cabling Standard
 - 6. ANSI/TIA-606-A: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
 - 7. ANSI/TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
 - 8. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Cabling Standard
 - 9. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
 - 10. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)
- B. Comply with all local, state and federal codes for telecommunications installations.

1.4 SYSTEM DESCRIPTION

- A. Design Requirements

1. All systems and equipment must comply with the Delaware State-Wide Information Technology and Architecture Standards, Latest Version.
2. LAN and Telephone Distribution:
 - a. Provide labor, materials, equipment, services and operations required for complete installation of LAN compatible with:
 - i. Ethernet 10Base-SX
 - ii. Ethernet 100Base-FX
 - iii. Ethernet 1000Base-SX
 - iv. Ethernet 1000Base-LX
 - v. Ethernet 10GBase-S
 - vi. Ethernet 10Base-LX4
 - vii. Ethernet 10GBase-L
 - viii. Ethernet 10GBase-LRM
 - ix. Fibre Channel 100-MX-SN-I
 - x. Fibre Channel 100-SM-LC-L
 - xi. Fibre Channel 200-MX-SN-I
 - xii. Fibre Channel 200-SM-LC-L
 - xiii. Fibre Channel 400-MX-SN-I
 - xiv. Fibre Channel 400-SM-LC-L
 - xv. Fibre Channel 1200-MX-SN-I
 - xvi. Fibre Channel 1200-SM-LL-L
 - xvii. FDDI PMD ANSI X3.166
 - xviii. FDDI SMF-PMD ANSI X3.134
 - b. All wiring including copper and fiber optic shall be in a star topology.
 - i. Category 6 UTP wiring terminates on Category 6 RJ-45 jack at workstation and on Category 6 rack-mounted patch panel in telecommunications room. Connections wire type ANSI/TIA-568A.
 - ii. Multi-strand composite fiber optic cable connects distribution racks between telecommunications rooms and terminates on rack-mounted fiber optic patch panel.
 - c. Network cables routed from distribution racks throughout building as shown on T-Drawings. Drop to outlet installed in conduit and wall box, or dual-channel surface mounted raceway to communications outlet in classrooms, offices, or other locations indicated on T-Drawings.
 - i. Refer to notes on each drawing to determine exact installation methods.
 - ii. Note and record all cable lengths to the nearest foot.
 - iii. Replace any cable exceeding 90 meters (295 feet) and route to reduce length to a minimum of 90 meters. Complete all cable rerouting for compliance at no additional cost to School district.
 - iv. Identify to Design consultant prior to installation of any cables that cannot be reduced to 90 meters or less in total length (rise and run).
 - v. Strictly adhere to most current version of ANSI/TIA Telecommunications cabling standards.
 - vi. Unless otherwise noted on T-Drawings, provide ladder-type cable tray from corridor to distribution racks and termination fields in telecommunication rooms.

- vii. Install “waterfall” device providing sweep from cable tray to data rack/cabinet and other vertical transitions.
 - d. Data and Telephone outlets: Category 6 rated RJ-45 type connectors with all four copper pairs terminated and tested in accordance with the 568B wiring standard.
 - e. Fiber Optic Horizontal and Backbone Cables: Terminate on panels in each rack and connectors with ceramic sleeves. Terminate and test all strands unless otherwise noted.
 - f. Permanently identify and label all cables and termination devices, at distribution rack and workstation in accordance with ANSI TIA 606 Standard or as agreed by Design consultant and school district.
 - g. Remove and replace any cables failing to meet end-to-end testing requirements; do not abandon cable in place. All cable shall be terminated at both ends, unless noted in T-Drawings.
- B. Performance Requirements
- 1. Comply with applicable requirements in Local, State and Federal Codes, ANSI/TIA Standards, and BICSI methodology.
- 1.5 SUBMITTALS
- A. Comply with requirements of Division 0 and Division 1 - Submittals are as modified below.
- B. Product Data: Submit manufacturer’s product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.
- 1. Communications outlets, faceplates, and accessories.
 - 2. Fiber optic cable, patch cables and termination devices.
 - 3. Copper cable, patch cables and termination devices.
 - 4. Inner duct and accessories.
 - 5. Rack configurations and wiring diagrams.
 - 6. Network cabling test equipment and process (routines).
 - 7. Equipment Racks
 - 8. Outlets
- C. Samples:
- 1. Provide samples of outlets and assemblies as described below, prior to installation, for approval by designer.
 - 2. Telecommunications outlets – Submit samples of telecommunications outlets to be provided including following components and characteristics:
 - a. Flush mounted and Raceway outlets – Completely assembled faceplate and wall box with each type of outlet to be mounted in faceplate, including blank covers, blank covers, labeling field, cabling, and adapter plates and bezels required.
 - b. Sample characteristics:
 - i. Provide all components in colors selected by Design consultant.
 - ii. Provide multiple outlet samples where required to accurately represent range of outlets to be provided.
- D. Shop Drawings
- 1. The Contractor shall submit shop drawings of all systems showing major components of the systems. Submit wiring diagrams showing connections for all systems and equipment.

- E. Quality Control Submittal
 - 1. Test Reports: Submit complete sample test data and reports with exact labels used on cables, patch panels and faceplates.
 - 2. Certificates
 - a. Manufacturer Certification: Submit certification from manufacturer of products to be installed under this contract certifying that Installer is authorized by manufacturer to install specified products.
 - b. Installer Experience Listing: Submit list of at least 5 completed projects as specified below in "Quality Assurance – Qualifications – Installer."
- F. Contract Closeout Submittal: Comply with requirements of Division 0, including submission of operating and maintenance instructions as item in "Operation and Maintenance Data" manual described in that Section.

1.6 QUALITY ASSURANCE

- A. All Work shall be installed in a first class, neat and workmanlike manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized school district personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of school district is obtained.
- B. Installer Qualifications: Qualified to cable, terminate and test data network cabling system specified in this Section, certified by manufacturer of products to be installed, and completed at least 5 computer network installations of similar size, nature and complexity as specified for this project.
- C. Conditions for Consideration of "Or Equal" Products: Where products are specified by name and accompanied by the term "or equal", the proposed "or equal" product will be considered when the following conditions are satisfied. If all the following conditions are not satisfied, Design Consultant will return requests without action, except to record noncompliance with these requirements:
 - 1. Proposed product does not require extensive revisions to the Contract Documents.
 - 2. With the exception of the product name or number and manufacturer's name, proposed product conforms with requirements indicated on the Drawings and in the Specifications in every respect and will produce indicated results.
 - 3. Proposed product is fully documented and properly submitted.
 - 4. Proposed product has received necessary approvals of authorities having jurisdiction.
 - 5. Proposed product is compatible with AND has been coordinated with other portions of the Work.
 - 6. Proposed product provides specified warranty.
 - 7. If proposed product involves more than one contractor, proposed product has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
 - 8. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.

9. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.
10. Submission is accompanied with proposed product's Manufacturer signed written statement on Manufacturer's letterhead, certifying that manufacturer complies with requirements in the Contract Documents.

1.7 WARRANTY

- A. Installer's Warranty: Provide manufacturer's system warranty against electrical or mechanical defects for 1 year from date of final acceptance.
- B. A fifteen (15) year Extended Product Warranty and Systems Assurance Warranty for this wiring system shall be provided by the Manufacturer as follows:
 1. Extended Product Warranty: The Extended Product Warranty shall ensure against product and workmanship defects, that all approved cabling components exceed the specifications of ANSI/TIA 568B and Addenda for fiber link/channels and copper components, for a fifteen (15) year period. The warranty shall apply to all passive components, including both cable and connecting hardware as a combined system. Any claims cover replacement costs on any defective product, both material and labor. Extended warranties beyond fifteen (15) years will be considered.
 2. System Assurance: The System Assurance shall cover the future of the wiring system to support the application which it was designed to support as well as additional application(s) introduced in the future by recognized standards or user forums that use the ANSI/TIA 568B component and link/channel specifications for cabling, for a fifteen (15) year period.
 3. System Certification: Upon successful completion of the installation and subsequent inspection, the School district shall be provided with a numbered certificate, from the manufacturing company, registering the installation.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. All materials shall be new and unused except as noted in T-series Drawings.
- B. All cables shall be plenum rated
- C. System wiring and equipment installation shall be in accordance with good engineering practices as established by ANSI/TIA and the NEC. Wiring shall meet all state and local electrical codes. All wiring shall test free from all grounds and shorts.
- D. Velcro straps shall be used for bundling wires. Wires shall be bundled loosely. Permanent cable ties are not acceptable.
- E. Wiring system shall consist of the following:
 1. Accessories and Appurtenances
 2. Cable Management Devices
 3. Fiber Optic Cable and Terminators (as indicated on drawings)
 4. Copper and Fiber Patch cables

5. Remote Jacks
6. Termination/Patch Panels
7. Twisted Pair Data Cables
8. The Cable Infrastructure Project requires a structured cabling system, or equivalent single-manufacturer solution. The Category 6 portion of the cabling system shall comply with the link and channel performance requirements of ANSI/TIA 568-B.2-1 "Performance Specifications for 4-pair 100 Ohm Category 6 Cabling". The cabling system shall be backed by a 15-Year System Warranty.
9. The work includes the provision for a complete and operable Local Area Network Building Data System consisting of active and non-active components. The cabling system and all wiring components shall meet and comprise an ANSI/TIA Category 6 Wiring System. With master and remote data equipment the completed system shall provide 1Gbs Fiber Optic Fast Ethernet communications backbone support to the edge switches and Ethernet 1000 BASE-T to the workstation data jacks. The system shall provide such services as computer networking, data transmission, graphics and other multi-media offerings.
10. Provide one home run cable from each data/voice jack to appropriate wiring closet.
11. Cable length of home run cable shall not exceed 90 meters.
12. All Modular jack panels shall be wired to ANSI/TIA 568B

2.2 J-HOOKS

- A. Cooper B-Line BCM-21, 23 or 64.
 1. Provide in sufficient quantity for 15% future expansion.
 2. Installed no more than 6' apart.
 3. Install in any areas without cable tray above false ceilings.

2.3 HORIZONTAL CABLES

- A. Category 6a 100 ohm UTP 23 AWG Wireless cables shall have a distinctive color. Submit for approval from design team.
 1. Hubbell C6ASxx
 2. Or approved equal from
 - a. Belden
 - b. Berk-Tek
 - c. Systemax
- B. Category 6 100 ohm UTP Voice, Data, Wireless and Security cables shall each have a distinctive color. Submit for approval from design team.
 1. Hubbell C6SPxx
 2. Hubbell C6RPxx
 3. Hitachi 30025-8
 4. Hitachi 30024-8
 5. Or approved equal from
 - a. Belden
 - b. Berk-Tek
 - c. Systemax

2.4 BACKBONE CABLES

- A. Multi-pair Cat 5e Riser Cables
 - 1. Hitachi 30093-50
 - 2. Hitachi 30172-100
 - 3. Or approved equal from
 - a. Mohawk
 - b. Belden
 - c. Berk-Tek

- B. SingleMode Fiber Optic Cables
 - 1. 12 Strand Hitachi 61459
 - 2. Or approved equal from
 - a. Corning
 - b. Berk-Tek

2.5 TERMINATION FIELDS

- A. Category 6a 48-Port Patch Panels. Patch panels shall be segregated for POE switches and non-POE switches.
 - 1. Provide 15% spare capacity
 - 2. Hubbell HP6A48
 - 3. Hubbell Rear Cable Manager
 - 4. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systemax
 - d. Leviton

- B. Category 6 48-Port Patch Panels. Patch panels shall be segregated for POE switches and non-POE switches.
 - 1. Provide 15% spare capacity
 - 2. Hubbell P6E48U
 - 3. Hubbell CBLMG1 Rear Cable Manager
 - 4. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systemax
 - d. Leviton

- C. Fiber Enclosure
 - 1. Hubbell 2U FCR350SP36R
 - 2. Hubbell 2U FCR350SP54R
 - 3. Hubbell 3U FCR525SPR
 - 4. Hubbell 4U FCR700SP
 - 5. Or approved equal from

- a. Ortronics
- b. Panduit
- c. Systemax
- d. Leviton

D. Fiber Adaptor Panels

1. Hubbell FSPSCDM6AQ
2. Hubbell FSPSCQM6AQ
3. Hubbell FSPSCDS6
4. Hubbell FSPSCQS3
5. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systemax
 - d. Leviton

E. Fiber Connector

1. Hubbell FCSC900K50GM12 50/125um OM4 Aqua
2. Hubbell FCSC900K50GM12 9/125 UPC
3. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systemax
 - d. Leviton

F. 110 Blocks

1. Hubbell 110BLK50FTK5
2. Hubbell 110BLK100FTK5
3. Hubbell 110BLK300FTK5
4. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systemax
 - d. Leviton

2.6 OUTLETS

A. Category 6a Wire Jess Jacks

1. Hubbell HXJ6Axx (replace xx with specified colors)
2. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systemax
 - d. Leviton

B. Category 6 Voice and Data Jacks

1. Hubbell HXJ6xx (replace xx with specified colors)

2. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systemax
 - d. Leviton

C. Faceplates

1. Hubbell IFP11xx
2. Hubbell IFP12xx
3. Hubbell IFP13xx
4. Hubbell IFP14xx
5. Hubbell IFP16xx
6. Hubbell IFP26xx
7. Hubbell IFP29xx
8. Hubbell IFP212xx
9. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systemax
 - d. Leviton

D. Frames

1. Hubbell ISF2xx
2. Hubbell ISF3xx
3. Hubbell ISF4xx
4. Hubbell ISF6xx
5. Hubbell NS620xx
6. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systemax
 - d. Leviton

2.7 PATCH CORDS

A. Cat 6a UTP Copper Patch Cords

1. Hubbell HC6Axx03
2. Hubbell HC6Axx05
3. Hubbell HC6Axx07
4. Hubbell HC6Axx010
5. Hubbell HC6Axx15
6. Hubbell HC6Axx20
7. Hubbell HC6Axx25
8. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systemax
 - d. Leviton

B. Cat 6 UTP Copper Patch Cords

1. Hubbell HC6xx03
2. Hubbell HC6xx05
3. Hubbell HC6xx07
4. Hubbell HC6xx010
5. Hubbell HC6xx15
6. Hubbell HC6xx20
7. Hubbell HC6xx25
8. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systemax
 - d. Leviton

C. Fiber Patch Cords

1. Hitachi Singlemode
2. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systemax
 - d. Leviton

2.8 CLASSROOM / CONFERENCE / COLLABORATION AREA CABLING

1. Audio
 - a. 3.5 MM Stereo terminated connectors
 - b. 18/2 AWG Speaker Wire

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine conditions under which telecommunications cabling and equipment and related components are to be installed in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Design Consultant in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected to ensure a safe and timely installation.
1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Design consultant written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.
 2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.
 3. Verify all dimensions in field and confirm condition of existing hardware to be utilized.

4. Confirm space requirements and physical confines of all work areas to ensure that all materials can be installed in indicated spaces.
5. Confirm all outlet locations and cable pathways and advise Design consultant in writing of any discrepancies or issues in Design described in Contract Documents.

3.2 PREPARATION

- A. Protection: Provide adequate protection of equipment and hardware before and after installation.
- B. Existing Communications Services: Ensure all telecommunications systems (voice, video and data) remain operational throughout the project.
 1. Identify any additional telecommunications outlets, circuits, and wiring at the site not shown on T-Drawings and interfering with installation of specified equipment.
 2. Contact local telephone, network and CATV company to identify all circuits providing existing services.
 3. Remove all accessible portions of abandoned communications cabling per NEC 800.52. Tag all communications cabling not terminated at both ends but retained for future use.

3.3 INSTALLATION

- A. Provide and install all components necessary to install complete telecommunications cabling and equipment systems, including (but is not limited to) connectors, patch cables, terminators, etc...
 1. Cable runs shall be continuous and unbroken from end to end. Splicing of any Telephone, LAN, or coaxial video distribution cable is prohibited. Horizontal cabling for LAN and telephone shall end in rack-mounted patch panels.
 2. Secure all horizontal cables within ceiling cavities to building structure.
 3. Loosely bundle all cables and support from structure at unequal intervals from 5 to 6 feet with spring steel fasteners and cable clip rated for use with high performance cables where cable tray or other support structure has not been provided as indicated on Drawings. All mounting clips shall be seismic type as per BOCA.
 4. Do not violate manufacturer's recommended loadings. Leave 30% capacity for future use of pathway.
 5. Verify all horizontal cable run lengths prior to installation. Re-distribute horizontal cabling to maintain clearance requirements and maintain pathway route accessibility.
 6. Do not support cables from ceiling grid T-Bars, grid wire supports or bridle rings. Do not allow cables to touch ceiling grid.
 7. Do not secure cables with permanent cable ties. Do not tighten cable bundles in such a way as to cause jacket deformation or damage.
 8. Provide a 10-foot service loop in all fiber optical cables to permit future cable splice and repair at all building entrance points and termination points.
 9. Place cables in compliance with ANSI/TIA-568.B standards and BICSI recommended methods.
 10. Tight 90-degree bends are unacceptable, and use of plastic "cinch-type" tie-wraps are not permitted, in order to prevent damage to cable jacket and compromise the cable's electrical or optical characteristics.

11. Cable bundles shall be neatly routed with a service loop to provide 10 feet of slack at the cross-connect end and as noted in the T-drawings. Cable bundles shall be secured using only black Velcro cable wraps.
12. 10 feet of service loop shall be provided in the ceiling at each workstation. Contractor shall not secure service loop in coils, but route in such a manner as to minimize EMI.
13. Wireless outlet locations
 - a. Wireless locations shown on T-series drawings shall be installed outside of a faceplate.
 - b. Ceiling shall be marked and as-builts shall reflect the location of all terminated ends and service loops as directed by SCHOOL DISTRICT personnel.
 - c. Cable shall be terminated in a female RJ-45 female jack, and left with a service loop as described in T-series drawings. Cable shall be tested and documented per previous requirements.
 - d. After completion of wireless site survey, outlet shall be re-terminated for connection to Wireless Access Point.

B. Determine allowable cable proximity to other electrical power sources of 480 Volts or less using ANSI/TIA-569E “Cabling Pathway Standard” for UTP cable separations from sources of EMI:

1. Minimum separation distance from Power Sources at 480 V or less:

CONDITION	< 2 kVA	2-5 kVA	> 5 kVA
a. Unshielded power lines or electrical equipment in proximity to open or non-metal pathways	6 in.	12 in.	24 in.
b. Unshielded power lines or electrical equipment in proximity to open or non-metal pathways	3 in.	6 in.	12 in.
c. Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to grounded metal conduit pathway	3 in.	6 in.	12 in.
d. Transformers & Elec. Motors	40 in.	40 in.	40 in.
e. Fluorescent Lighting	12 in.	12 in.	12 in.

C. Fiber Optical Cable Installation Requirements

1. Install all interior fiber optic backbone cables in 1-inch plenum-rated inner duct, similar to Pyramid Industries #PLM100(T) where fiber optical cable placed in cable tray or otherwise fully supported in accordance with manufacturer’s requirements.
2. Install all outdoor rated communications cables not rated for plenum placement in interior environments in metallic conduit, according to NEC Articles 770 and 800.

3. Install inner duct for fiber optic cabling in all conduits, as necessary for proper support of cables, or where required to assure pull-in tension not exceeding manufacturer's recommendations.
4. Provide pull strings or ropes in all conduit and inner duct used for communications cables.

D. Cabling System

1. Where not provided as part of the electrical work or the data/voice work, the Contractor shall furnish and install necessary conduit, raceways, pull boxes, outlet boxes and cable to provide a complete system as herein specified. All wiring shall be tested for continuity and freedom of all grounds and short-circuits. All outlet boxes shall be as specified for other wiring devices; size as required by equipment manufacturer.
2. Cables shall be installed in raceways or EMT, as detailed on the drawings and/or as specified, above non-accessible ceilings, where exposed, and wherever they may be subject to physical damage. Where not provided as part of the electrical work or the data/voice work, the Contractor shall provide a raceway (conduit) from each outlet to above the accessible ceiling. Otherwise, cable shall be installed above accessible suspended tile ceilings and attached to building structure with approved bridle rings or J-hooks, cable is not permitted to rest on ceiling. The cable routes used shall avoid steam lines, power wiring and other utilities that may adversely affect the system's performance or result in damage to the cable. If the routes required place the cable in proximity to these utilities, the cable shall be suitably protected. Under no circumstances shall cable be run in hangers used for pipes or electric conduits nor shall the cable be supported in any way by attachment to these pipes, conduits or ceiling hangers.
3. During the installation work, improper bending, stretching, twisting, kinking, pinching or any other improper handling must not deform the cable. All cable runs shall contain "S" loops or other means to accommodate expansion and contraction. Coaxial cables shall not bend at any point of installation to a radius of less than ten times the diameter of the cable or less than the value recommended by the cable manufacturer. Cable connected to electronic equipment in the system shall be tagged to show its function and the location of its other end. All labels shall be of durable material and securely fastened to the cable.
4. All cables shall be fastened securely with suitable hardware so as to avoid sharp bends and to prevent rubbing against sharp corners and in a manner to prevent injury or physical distortion.
5. Wiring for all wall-mounted equipment shall be concealed in raceway (conduit) from outlet to above removable ceilings, unless noted otherwise.
6. Wiring installed above removable ceilings shall be installed on bridle rings. No cables shall be installed on roof or exterior of building.
7. All cable structure properly terminated on backboard, neatly arranged in orderly fashion and accurately identified.
8. Equipment cabinet(s) anchored to wall or floor utilizing an approved method.
9. Install all exposed cabling in surface raceway by Wiremold, Hubbell or Panduit where in-wall conduit has not been provided. Follow all manufacturers' guidelines requirements regarding bending radius and slack. All bends, offsets and fittings shall be appropriately sized to provide 30% capacity after installation.

- E. Install all cable in accordance with National, state and local codes and ANSI/TIA Standards, and BICSI methods.
 - 1. Follow manufacturer's guidelines and requirements for all cable termination.
 - 2. Install and connect #6 AWG to bond all equipment racks, conduits and cable trays to busbar in each telecom room. Each telecom room shall be interconnected to TER with #3 AWG bonding backbone to TMGB per Telecommunications Grounding Diagram. It shall be left to licensed electrician to interconnect TMGB with lowest point of building ground. Contractor shall verify TMGB has been bonded to building ground before declaring completion.
- F. Permanently identify all system components following ANSI/TIA-606A "Administration Standard for Commercial Telecommunications Infrastructure" with identification format:
 - 1. Identification: Provide permanent identification labels for outlets, face plates, patch panels, access panels and entrance facilities.
 - 2. Each individual cable shall be labeled on both ends of cable terminations regardless of cable intended use. Labels must be machine printed with permanent black ink on laminated white label material. Contractors must check with appropriate school district personnel for appropriate labeling scheme. The intended format and labeling material must be approved by school district Technology Department before labeling begins.

3.4 TESTING

A. LAN and Telephone

- 1. Upon completion of work, all parts of the telecommunications installation shall be tested by the Telecommunications Contractor and demonstrated free of any defects. Preliminary testing will be permitted but shall not be accepted in lieu of obtaining final test results. Final test results shall be accomplished by the use of proper test equipment for the system being tested.
- 2. Re-terminate and re-test any cables or pairs of cables failing end-to-end testing requirements. Replace any faulty cables/pairs or termination devices. Remove all defective cables completely from pathways.

B. As-Builts

- 1. Accurate as-built drawings shall be provided in electronic and hard copy format.
 - a. Drawings shall accurately show and describe all cable routing and equipment location in redline format.
 - b. 3 copies of electronic (CAD) drawings shall be distributed on appropriate media: 1 to construction management, 1 to designers and 1 to the school district.
 - c. 3 hard copies of CAD drawings shall be plotted on full size sheets and test results of every installed cable have been given to the construction management for appropriate distribution.

3.5 ACCEPTANCE

- A. Contractors work shall be considered complete after the following conditions have been met:
1. Cable installation is complete and all cable runs have been tested and documented to be installed according to specifications and drawings.
 2. A school district Technology representative has successfully tested the “LIVE” system.
 3. All punch list items have been reconciled.
 4. All disturbed ceiling panels, firestopping materials, covers, etc. have been properly reinstalled.
 5. All materials and trash have been removed from the site.
 6. A 1-Year Installers warranty has been given to a school district Technology representative.
 7. Submit Manufacturers Extended Warranty Application.

END OF SECTION

NOT FOR BID

SECTION 27 40 00 - CLASSROOM SOUND ENHANCEMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Classroom Sound Enhancement System

1.2 DEFINITIONS

- A. "Sound Enhancement" refers to a stand-alone sound system which includes speakers, speaker wire, an infrared microphone and receiver, a pendant style microphone and amp/mixer unit.
- B. "Communications Network Outlet (CNO)" refers to a collection of one or more mechanical cable termination device for horizontal cable in the work area.
- C. "Drop" refers to the vertical transition to a location of one or more CNOs.
- D. "Horizontal Cabling" refers to the cabling between and including the work area communications network outlet and the horizontal cross-connect in the telecommunications room.
- E. "Jack" refers to a female-style telecommunication receptacle.

1.3 SYSTEM DESCRIPTION

A. Design Requirements

1. Classroom Sound distribution through a pendant style portable microphone and at least one hand held microphone per learning area.
2. Amplifier/Receiver must have audio inputs for at least three auxiliary devices and an additional input to allow transferring of sound to ceiling speakers from the microphone.
3. All stand-alone sound systems must have call override from the Intercom/PA system in the case of an emergency.

B. Performance Requirements

1. Comply with applicable requirements in Local, State and Federal Codes, ANSI/TIA Standards, and ETC SI methodology.
2. Specified cabling system derived from recommendations in approved telecommunications industry codes, standards and methods, including the following documents:
3. ANSI/TIA-568-1-E: Commercial Building Telecommunications Cabling
4. ANSI/TIA-568-2-D: Balanced Twisted Pair Cabling and Components
5. ANSI/TIA-568-3-D: Optical Fiber Cabling Components
6. ANSI/TIA-569-E: Telecommunications Pathways and Spaces
7. ANSI/TIA-570-B: Residential Telecommunications Cabling Standard
8. ANSI/TIA-606-A: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
9. ANSI/TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
10. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Cabling Standard

11. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
12. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

1.4 SUBMITTALS

- A. Comply with requirements of Division 0 and Division 1 - Submittals and as modified below.
- B. All systems and equipment must comply with the Delaware State-Wide Information Technology and Architecture Standards, Latest Version.
- C. Product Data: Submit manufacturer's product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.
 1. Sound Amplifier
 2. Sound Speakers
- D. Samples: Provide samples of equipment, cables, microphones and assemblies as described below, prior to installation, for approval by designer.
 1. Sound Enhancement – Submit samples of audio-visual cables provided including following components and characteristics:
 - a. Sample characteristics:
 - i. Provide all components in colors selected by Design Consultant.
 - ii. Provide multiple samples where required to accurately represent range of cables to be provided.
- E. Shop Drawings
 1. The Contractor shall submit shop drawings of all systems showing major components of the systems. Submit wiring diagram showing connections for all systems and equipment.
- F. Quality Control Submittal
 1. Test Reports: Submit complete sample test data and reports with exact labels used on cables and faceplates
 2. Certificates
 - a. Manufacturer Certification: Submit certification from manufacturer of products to be installed under this contract certifying that Installer is authorized by manufacturer to install specified products.
 - b. Installer Experience Listing: Submit list of at least 5 completed projects as specified below in "Quality Assurance – Qualifications – Installer."
- G. Contract Closeout Submittal: Comply with requirements of Division 0, including submission of operating and maintenance instructions as item in "Operation and Maintenance Data" manual described in that Section.

1.5 QUALITY ASSURANCE

- A. All Work shall be installed in a first class, neat and professional manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized school district personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of the school district is obtained.

- B. Installer Qualifications: Qualified to cable, terminate and test cabling system specified in this Section, certified by manufacturer of products to be installed, and completed at least 5 installations of similar size, nature and complexity as specified for this project.
- C. Conditions for Consideration of "Or Equal" Products: Where products are specified by name and accompanied by the term "or equal", the proposed "or equal" product will be considered when the following conditions are satisfied. If all the following conditions are not satisfied, Design Consultant will return requests without action, except to record noncompliance with these requirements:
 - 1. Proposed product does not require extensive revisions to the Contract Documents.
 - 2. With the exception of the product name or number and manufacturer's name, proposed product conforms with requirements indicated on the Drawings and in the Specifications in every respect and will produce indicated results.
 - 3. Proposed product is fully documented and properly submitted.
 - 4. Proposed product has received necessary approvals of authorities having jurisdiction.
 - 5. Proposed product is compatible with AND has been coordinated with other portions of the Work.
 - 6. Proposed product provides specified warranty.
 - 7. If proposed product involves more than one contractor, proposed product has been coordinated with other portions of the Work, is uniform and consistent, compatible with other products, and is acceptable to all contractors involved.
 - 8. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
 - 9. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.
 - 10. Submission is accompanied with proposed product's Manufacturer signed written statement on Manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents.

1.6 WARRANTY

- A. Installer's Warranty: Provide manufacturer's system warranty against electrical or mechanical defects for 1 year from date of final acceptance.
 - 1. System Certification: Upon successful completion of the installation and subsequent inspection, the Authority shall be provided with a numbered certificate, from the manufacturing company, registering the installation.

PART 2 - PRODUCTS

2.1 MATERIALS - ALL MATERIALS SHALL BE NEW AND UNUSED

A. Acceptable Products

- 1. Classroom Sound Reinforcement System.
 - a. Lightspeed 975 Access System (mounted to wall, coordinate with architect and owner prior to installation)

B. J-Hooks

1. Cooper B-Line BCM-21, 23 or 64.
 - a. Provide in sufficient quantity for 15% future expansion.
 - b. Installed no more than 6' apart.
 - c. Install in any areas without cable tray above false ceilings.

C. Classroom Sound Equipment (Lightspeed 975 Access)

1. Receiver / amplifier specifications
 - a. Power output: 20W
 - b. Frequency response: 60 Hz to 7 kHz
 - c. Power supply (UL Listed): 24V/2.5A
 - d. Total Harmonic Distortion: <1% @ 10 Watts
 - e. Controls:
 - i. Power switch with LED
 - ii. Auxiliary audio input volume controls
 - iii. Speaker on/off switches for zoning
 - iv. Mixed audio output level controls
 - f. Page mute sensitivity level control
 - g. Connections:
 - i. Speaker outputs (Euro-block connectors)
 - ii. Mixed audio inputs (3.5mm)
 - iii. DC Power input
 - iv. Page mute input (Euro-block)
 - h. The receiver/amplifier shall be manufactured using lead-free processes and free of other materials harmful to the environment (RoHS compliant).
 - i. The receiver/amplifier shall be CE certified.
2. Pendant-style microphone transmitter
 - a. Description: the pendant-style transmitter shall be capable of being worn around a teacher's neck as a hands-free microphone via the lavalier cord or to be used as a handheld student pass-around microphone. The mic must be rechargeable via cradle charger and must have alkaline charge protection.
 - b. 1.9 GHz Wireless Communication
 - c. Audio distortion: <1%
 - d. Battery Charger: cradle charger
 - e. Battery Power: One 2.4V NiMH battery pack
 - f. Dimensions: 2.9" (h) x 1.1" (w) x 1.0" (d)
 - g. Weight (with battery): 1.8 oz.
 - h. The pendant-style transmitter shall be manufactured using lead-free processes and free of other materials harmful to the environment (RoHS compliant).
 - i. The pendant-style transmitter shall be CE certified.
3. Page First Clip
 - a. Unit shall provide shunt of local sound.
4. Speakers

- a. Ceiling Speaker (four speakers for rooms of 1600 sq. ft. or less)
 - b. Description: two-way speaker system
 - c. Driver Size: 6.5" driver; 1" tweeter
 - d. Frequency Response: 40 Hz – 20 kHz ± 6dB
 - e. Impedance: 8 Ω
 - f. Power Handling: 30 W
 - g. Enclosure: white ABS ceiling-mount housing with metal grille; ABS back-enclosure
 - h. Tile Support: 20-gauge metal tile bridge
5. Cable
- a. Speaker Cable:
 - i. Class 2, or better plenum rated. (16/2 AWG shielded)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine conditions under which AV cabling and sound enhancement equipment and related components are to be installed in coordination with Installer of materials and components specified in this Section and notify selected Prime Contractors and Design consultant in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected to ensure a safe and timely installation.
1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Design consultant written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.
 2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.
 3. Verify all dimensions in field and confirm condition of existing hardware to be utilized.
 4. Confirm space requirements and physical confines of all work areas to ensure that all materials can be installed in indicated spaces.
 5. Confirm all outlet locations and cable pathways and advise Design consultant in writing of any discrepancies or issues in Design described in Contract Documents.

3.2 PREPARATION

- A. Protection: Provide adequate protection of equipment and hardware before and after installation.
- B. Existing Communications Services: Ensure all telecommunications systems (voice, video and data) remain operational throughout the project.
1. Identify any additional outlets, circuits, and wiring at the site not shown on T-Drawings and interfering with installation of specified equipment.
 2. Remove all accessible portions of abandoned communications cabling per NEC 800.52. Tag all communications cabling not terminated at both ends but retained for future use.

3.3 INSTALLATION

- A. Provide and install all components necessary to install complete AV cabling and sound enhancement equipment systems, including (but is not limited to) connectors, electronics, terminators, pass-thrus, cables etc...
1. Cable runs shall be factory terminated. Splicing of any cable is prohibited
 2. Secure all cables within ceiling cavities to building structure.
 3. Loosely bundle all cables and support from structure at unequal intervals from 5 to 6 feet with spring steel fasteners and cable clip rated for use with high performance cables where cable tray or other support structure has not been provided as indicated on Drawings. All mounting clips shall be seismic type as per BOCA.
 4. Do not violate manufacturer's recommended loadings. Leave 30% capacity for future use of pathway.
 5. Verify all horizontal cable run lengths prior to installation. Ensure cables do not exceed distances that would degrade the signal transmission requirements
 6. Do not support cables from ceiling grid T-Bars, grid wire supports or bridging rings. Do not allow cables to touch ceiling grid.
 7. Install cables in EMT in all unfinished or exposed areas
 8. Do not secure cables with permanent cable ties. Do not tighten cable bundles in such a way as to cause jacket deformation or damage.
 9. Place cables in compliance with ANSI/TIA/standards and BICSI recommended methods.
 10. Tight 90-degree bends are unacceptable and use of plastic "cable-type" tape-wraps are not permitted, in order to prevent damage to cable jacket and compromise the cable's electrical or optical characteristics.
 11. Communications outlets shall be located to be no more than 6 feet from an electrical outlet.

- B. Determine allowable cable proximity to other electrical power sources of 480 Volts or less using ANSI/TIA-569E "Cabling Pathway Standards" for UTP cable separations from sources of EMI:

1. Minimum separation distance from Power Source at 480 V or less:

CONDITION	<u>≤ 2kVA</u>	<u>2-5 Kva</u>	<u>≥ 5 kVA</u>
a. Unshielded power lines or electrical equipment in proximity to open or non-metal pathways	3 in.	6 in.	12 in.
b. Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to grounded metal conduit pathway	3 in.	6 in.	12 in.
c. Transformers & Elec. Motors	40 in.	40 in.	40 in.
d. Fluorescent Lighting	12 in.	12 in.	12 in.

- C. Install all cable in accordance with National, state and local codes and TIA/EIA Standards, and BICSI methods.

1. Follow manufacturer's guidelines and requirements for all cable termination.

- D. Permanently identify all system components following TIA/EIA-606A "Administration Standard for Commercial Telecommunications Infrastructure" with identification format:

1. Identification: Provide permanent identification labels for outlets, faceplates and cables.
2. Each individual cable shall be labeled on both ends of cable terminations regardless of cable intended use. Labels must be machine printed with permanent black ink on laminated white label material. Contractors must check with appropriate school district personnel for appropriate labeling scheme. The intended format and labeling material must be approved by the school district Technology Department before labeling begins.

3.4 TESTING

A. Sound Systems

1. The contractor shall test all aspects of the Systems once it is installed and demonstrate these functions to the owner or owner's representative.
 - a. Speaker levels shall be verified to function individually and as a unit.
 - b. Control of the system shall be shown to control all aspects of the systems.
 - c. Levels shall be set for all outputs.
 - d. Microphones shall be demonstrated to work as intended by the manufacturer.

3.5 AS-BUILTS

- A. As-builts shall be provided by the contractor in hardcopy and electronic PDF format prior to completion.
- B. As-builts by contractor must include parts lists and wiring diagrams that clearly indicate all equipment, locations, wiring and connections.
- C. Owner's manuals shall be supplied as part of the as-built documentation.

3.6 DEMONSTRATION AND TRAINING

- A. All aspects of the systems must be demonstrated for the owner at the time of training
- B. A minimum of 8 hours of training shall be provided.
- C. Training shall be video and audio recorded for the owner and turned over to the owner at acceptance.

3.7 ACCEPTANCE

- A. Contractors work shall be considered complete after the following conditions have been met:
 1. Cable installation is complete and all cable runs have been tested and documented to be installed according to specifications and drawings.
 2. Equipment installation is complete and all functions have been tested and documented to function as designed and per the manufacturer's recommendations.
 3. All punch list items have been reconciled.
 4. All disturbed ceiling panels, fire stopping materials, covers, etc. have been properly reinstalled.
 5. A 1 Year Installers warranty has been given to a school district Technology representative.
 6. Submit Manufacturers Extended Warranty Application.

END OF SECTION

SECTION 27 41 00 - AUDIO VISUAL AND SOUND SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Electronic Displays (Owner Furnished, Contractor Installed)
2. Gymnasium Auxiliary Sound System
3. Cafeteria Auxiliary Sound System

1.2 DEFINITIONS

- A. "Communications Network Outlet (CNO)" refers to a collection of one or more mechanical cable termination device for horizontal cable in the work area.
- B. "Drop" refers to the vertical transition to a location of one or more CNOs.
- C. "Horizontal Cabling" refers to the cabling between and including the work area communications network outlet and the horizontal cross-connect in the telecommunications room.
- D. "Jack" refers to a female-style telecommunication receptacle.

1.3 SYSTEM DESCRIPTION

A. Design Requirements

1. A/V Systems
 - a. Electronic displays shall consist of 75" interactive panels and wall-mounted LCD / LED displays.
 - b. Gymnasium Sound Reinforcement System - A multi-loudspeaker system shall be provided. Clearly label and color code the master volume control for all functions.
 - c. Cafe Sound Reinforcement System - A multi-loudspeaker system shall be provided. Clearly label and color code the master volume control for all functions.
 - d. Hearing Assistance System - Provide a reinforcement system for the hearing impaired for each system. The hearing assistance system shall be an FM radio system that shall not limit operation to certain seats or areas of the room(s). Provide approximately 20-40 milliseconds of high-quality digital signal delay to help in the localization of the sound source.
2. All stand-alone sound systems must have call override from the Intercom/PA system in the event of an emergency.

B. Performance Requirements

1. Comply with applicable requirements in Local, State and Federal Codes, ANSI/TIA Standards, and BICSI methodology.
2. Specified cabling system derived from recommendations in approved telecommunications industry codes, standards and methods, including the following documents:
 - a. ANSI/TIA-568-1-E: Commercial Building Telecommunications Cabling

- b. ANSI/TIA-568-2-D: Balanced Twisted Pair Cabling and Components
- c. ANSI/TIA-568-3-D: Optical Fiber Cabling Components
- d. ANSI/TIA-569-E: Telecommunications Pathways and Spaces
- e. ANSI/TIA-570-B: Residential Telecommunications Cabling Standard
- f. ANSI/TIA-606-A: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
- g. ANSI/TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
- h. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Cabling Standard
- i. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
- j. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

1.4 SUBMITTALS

- A. Comply with requirements of Division 0 and Division 1 - Submittals and as modified below
- B. All systems and equipment must comply with the Delaware State-Wide Information Technology and Architecture Standards, Latest Version.
- C. Product Data: Submit manufacturer's product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.
 1. Sound coverage and pressure level diagram for each auxiliary sound system
 2. Sound Amplifier
 3. Sound Speakers
 4. Sound Microphones
 5. Sound Cabling and Wiring
 6. Connectors
 7. Mixers
 8. Controllers
 9. Amplifiers
 10. Communications outlets, face plates, and accessories.
 11. Wall outlets
- D. Samples: Provide samples of equipment, cables, microphones and assemblies as described below, prior to installation, for approval by designer.
 1. Sound Systems – Submit samples of audio/visual cables provided including following components and characteristics:
 - a. Sample characteristics:
 - i. Provide all components in colors selected by Design consultant.
 - ii. Provide multiple samples where required to accurately represent range of cables to be provided.
- E. Shop Drawings
 1. The Contractor shall submit shop drawings of all systems showing major components of the systems. Submit wiring diagrams showing connections for all systems and equipment.
- F. Quality Control Submittal

1. Test Reports: Submit complete sample test data and reports with exact labels used on cables and faceplates.
 2. Certificates
 - a. Manufacturer Certification: Submit certification from manufacturer of products to be installed under this contract certifying that Installer is authorized by manufacturer to install specified products.
 - b. Installer Experience Listing: Submit list of at least 5 completed projects as specified below in "Quality Assurance – Qualifications – Installer."
- G. Contract Closeout Submittal: Comply with requirements of Division 0, including submission of operating and maintenance instructions as item in "Operation and Maintenance Data" manual described in that Section.

1.5 QUALITY ASSURANCE

- A. All Work shall be installed in a first class, neat and professional manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized school district personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of the school district is obtained.
- B. Installer Qualifications: Qualified to cable, terminate and test cabling systems specified in this Section, certified by manufacturer of products to be installed, and completed at least 5 installations of similar size, nature and complexity as specified for this project.
- C. Conditions for Consideration of "Or Equal" Products: Where products are specified by name and accompanied by the term "or equal", the proposed "or equal" product will be considered when the following conditions are satisfied. If all the following conditions are not satisfied, Design Consultant will return requests without action, except to record noncompliance with these requirements:
 1. Proposed product does not require extensive revisions to the Contract Documents.
 2. With the exception of the product name or number and manufacturer's name, proposed product conforms with requirements indicated on the Drawings and in the Specifications in every respect and will produce indicated results.
 3. Proposed product is fully documented and properly submitted.
 4. Proposed product has received necessary approvals of authorities having jurisdiction.
 5. Proposed product is compatible with AND has been coordinated with other portions of the Work.
 6. Proposed product provides specified warranty.
 7. If proposed product involves more than one contractor, proposed product has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
 8. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
 9. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.
 10. Submission is accompanied with proposed product's Manufacturer signed written statement on Manufacturer's letterhead, certifying that manufacturer complies with requirements in the Contract Documents.

1.6 WARRANTY

- A. Installer's Warranty: Provide manufacturer's system warranty against electrical or mechanical defects for 1 year from date of final acceptance.
 - 1. System Certification: Upon successful completion of the installation and subsequent inspection, the Authority shall be provided with a numbered certificate, from the manufacturing company, registering the installation.

PART 2 - PRODUCTS

2.1 MATERIALS – ALL MATERIALS SHALL BE NEW AND UNUSED

A. Acceptable Products

- 1. The Auxiliary Sound and A/V Equipment is based on Extron, Community, Biamp, Sonore, Middle Atlantic, Epson and other like reputable manufacturers.
 - a. Equipment substitutions must be submitted in writing to the design team for review and approval.
 - b. Any equipment not meeting the design criteria will be rejected at the contractor's expense.

B. J-Hooks

- 1. Cooper B-Line BCM-21, 23 or 64.
 - a. Provide in sufficient quantity for 15% future expansion.
 - b. Installed no more than 6' apart.
 - c. Install in any areas without cable tray above the false ceilings.

C. Electronic Displays

- 1. 75" LCD Display (Owner Furnished, Contractor Installed)
 - a. Newline Interactive Panel with onboard computing and mount
 - b. Copernicus iRover Mobile Cart for:
 - i. Stage
 - ii. Media Center

- 2. 55" LCD Display (Owner Furnished, Contractor Installed)

- a. TEC V554

D. Gymnasium Equipment: (substitutions must provide equal or greater performance)

Equipment Cabinet

- a. Middle Atlantic DWR 24 RU swing open wall cabinet with Plexi Door.

2. Controller

- a. Biamp TEC-1S

3. Assistive Listening Equipment

- a. Listen Technologies LS-54-072
4. Wireless Microphone Equipment
 - a. Shure SLX124/85/sm58
5. CD Player
 - a. Denon DN-300z
6. DSP
 - a. Biamp Tesiraforte DAN AI
7. Power Sequencer
 - a. SurgeX SEQ 2 RU
8. Equipment Drawer
 - a. Atlas SD4-14 Drawer
9. Two Channel Amplifier
 - a. Crown CDi 1000
10. Mic Level Input
 - a. Neutrik Combo ¼" XLR
11. Line Level Input
 - a. RDL D-CIJ3.
12. Wired Microphone
 - a. Shure SM58S (Provide 3)
13. Microphone Stands
 - a. Atlas TEB (Provide 3)
14. Loudspeakers
 - a. Electro Voice SW100+
15. Remote Control
 - a. Crestron MC4
 - b. Crestron ANT-EXT-10
 - c. Crestron TSR-310
16. Wiring
 - a. Multi-conductor control cable.
 - b. 18/2 AWG Speaker Wiring
 - c. 14/2 AWG Speaker Wiring
 - d. VGA

- e. 3.5 mm audio
 - f. Cat 6 UTP
 - g. Shielded Cat 5e or greater UTP for audio faceplate cables.
 - h. West Penn 226, or equal, for the loudspeaker cluster circuits.
17. Miscellaneous Connectors
- a. Provide Neutrik NC3 series “XLR”, Neutrik NP3C “TRS” or Canare F-09 “RCA” connectors.
 - b. Provide Switchcraft N112B connectors.
 - c. Wirenuts are not acceptable.
- E. Cafeteria Equipment: (substitutions must provide equal or greater performance)
- 1. Equipment Cabinet
 - a. Middle Atlantic DWR 24 RU swing open wall cabinet with Plexi Door
 - 2. Controller
 - a. Biamp TEC-1S
 - 3. Assistive Listening Equipment
 - a. Listen Technologies LS-54-072
 - 4. Wireless Microphone Equipment
 - a. Shure SLX124/85/sm58
 - 5. CD Player
 - a. Denon DN-300z
 - 6. DSP
 - a. Biamp Tesiraforte DAN A
 - 7. Power Sequencer
 - a. SurgeX SEQ 2
 - 8. Equipment Drawer
 - a. Atlas SD4-14 Drawer
 - 9. Two Channel Amplifier
 - a. Crown XLC 12300
 - b. Crown CDI 1000
 - 10. Mic Level Input
 - a. Neutrik Combo ¼” XLR
 - 11. Line Level Input
 - a. RDL D-CIJ3.

12. Wired Microphone
 - a. Shure SM58S (Provide 3)
13. Microphone Stands
 - a. Atlas TEB-E (Provide 3)
14. Loudspeakers
 - a. JBL CBT1000 +CBT 1000E
 - b. JBL V2-15S Subwoofer
15. Remote
 - a. Crestron MC4
 - b. Crestron ANT-EXT-10
 - c. Crestron TSR-310
16. Wiring
 - a. Multi-conductor control cable.
 - b. 18/2 AWG Speaker Wiring
 - c. 14/2 AWG Speaker Wiring
 - d. VGA
 - e. 3.5 mm audio
 - f. Cat 6 UTP
 - g. Shielded Cat 5e or greater UTP for audio interconnect cables.
 - h. West Penn 226, or equal, for the loudspeaker cluster circuits.
17. Miscellaneous Connectors
 - a. Provide Neutrik NC3 series "XLR", Neutrik NP3C "TRS" or Canare F-09 "RCA" connectors.
 - b. Provide Switchcraft NI 1/8" B connectors.
 - c. Wirenuts are not acceptable.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine conditions under which AV cabling and sound enhancement equipment and related components are to be installed in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Design consultant in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected to ensure a safe and timely installation.
 1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Design consultant written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.
 2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.

3. Verify all dimensions in field and confirm condition of existing hardware to be utilized.
4. Confirm space requirements and physical confines of all work areas to ensure that all materials can be installed in indicated spaces.
5. Confirm all outlet locations and cable pathways and advise Design consultant in writing of any discrepancies or issues in Design described in Contract Documents.

3.2 PREPARATION

- A. Protection: Provide adequate protection of equipment and hardware before and after installation.
- B. Existing Communications Services: Ensure all telecommunications systems (voice, video and data) remain operational throughout the project.
 1. Identify any additional outlets, circuits, and wiring at the site not shown on T-Drawings and interfering with installation of specified equipment.
 2. Remove all accessible portions of abandoned communications cabling per NEC 800.5. Tag all communications cabling not terminated at both ends but retained for future use.

3.3 INSTALLATION

- A. Provide and install all components necessary to install complete AV cabling and sound enhancement equipment systems, including (but is not limited to) connectors, electronics, terminators, pass-thrus, cables etc...
 1. Cable runs shall be factory terminated. Splicing of any cable is prohibited.
 2. Secure all cables within ceiling cavities to building structure.
 3. Loosely bundle all cables and support from structure at unequal intervals from 5 to 6 feet with spring steel fasteners and cable clip rated for use with high performance cables where cable tray or other support structure has not been provided as indicated on Drawings. All mounting clips shall be seismic type as per BOCA.
 4. Do not violate manufacturer's recommended loadings. Leave 30% capacity for future use of pathway.
 5. Verify all horizontal cable run lengths prior to installation. Ensure cables do not exceed distances that would degrade the signal transmission requirements.
 6. Do not support cables from ceiling grid T-Bars, grid wire supports or bridle rings. Do not allow cables to touch ceiling grid.
 7. Install cables in EMT in all unfinished or exposed areas.
 8. Do not secure cables with permanent cable ties. Do not tighten cable bundles in such a way as to cause jacket deformation or damage.
 9. Place cables in compliance with ANSI/TIA/standards and BICSI recommended methods.
 10. Tight 90-degree bends are unacceptable and use of plastic "cinch-type" tie-wraps are not permitted, in order to prevent damage to cable jacket and compromise the cable's electrical or optical characteristics.
 11. Communications outlets shall be located to be no more than 6 feet from an electrical outlet.
- B. Determine allowable cable proximity to other electrical power sources of 480 Volts or less using ANSI/TIA-569E "Cabling Pathway Standard" for UTP cable separations from sources of EMI:
 1. Minimum separation distance from Power Source at 480 V or less:

CONDITION	<u>< 2kVA</u>	<u>2-5 Kva</u>	<u>> 5 kVA</u>
a. Unshielded power lines or electrical	3 in.	6 in.	12 in.

equipment in proximity to open or non-metal pathways

b. Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to grounded metal conduit pathway	3 in.	6 in.	12 in.
c. Transformers & Elec. Motors	40 in.	40 in.	40 in.
d. Fluorescent Lighting	12 in.	12 in.	12 in.

C. Install all cable in accordance with National, state and local codes and ANSI/TIA Standards, and BICSI methods.

1. Follow manufacturer's guidelines and requirements for all cable termination.

D. Permanently identify all system components following ANSI/TIA-606A "Administration Standard for Commercial Telecommunications Infrastructure" with identification format:

1. Identification: Provide permanent identification labels for outlets, receptacles and cables.
2. Each individual cable shall be labeled on both ends of cable terminations regardless of cable intended use. Labels must be machine printed with permanent black ink on laminated white label material. Contractors must check with appropriate school district personnel for appropriate labeling scheme. The intended format and labeling material must be approved by the school district Technology Department before labeling begins.

3.4 TESTING

A. A/V and Sound Systems

1. The contractor shall test all aspects of the Audio/Visual Systems once it is installed and demonstrate these functions to the owner or owner's representative.
 - a. Speaker levels shall be verified to function individually and as a unit.
 - b. Video Displays shall be verified to display from all input sources.
 - c. Control of the system shall be shown to control all aspects of the systems.
 - d. Levels shall be set for all outputs.
 - e. EDID and HDCP compliance shall be setup and verified.
 - f. Microphones shall be demonstrated to work as intended by the manufacturer.

B. Audio Visual Cables

1. The contractor shall test all cables included in the harness for proper signal transmission based on manufacturer standards.
2. The contractor shall record remove any cable that does not meet manufacturer standards and replace it with a correctly functioning cable.
3. The contractor shall demonstrate that the installed cables meet manufacturer standards for signal transmission prior to the job being considered complete.

3.5 AS-BUILTS

A. As-builts shall be provided by the contractor in hardcopy and electronic CAD format prior to completion.

- B. As-builts by contractor must include parts lists and wiring diagrams that clearly indicate all equipment, locations, wiring and connections.
- C. Owner's manuals shall be supplied as part of the as-built documentation.

3.6 DEMONSTRATION AND TRAINING

- A. All aspects of the systems must be demonstrated for the owner at the time of training
- B. A minimum of 16 hours of training shall be provided.
- C. Training shall be video and audio recorder for the owner and turned over to the owner at acceptance.

3.7 ACCEPTANCE

- A. Contractors work shall be considered complete after the following conditions have been met:
 - 1. Cable installation is complete and all cable runs have been tested and documented to be installed according to specifications and drawings.
 - 2. Equipment installation is complete and all functions have been tested and documented to function as designed and per the manufacturer's recommendations.
 - 3. All punch list items have been reconciled.
 - 4. All disturbed ceiling panels, fire stopping materials, covers, etc. have been properly reinstalled.
 - 5. A 1-Year Installers warranty has been given to a school district Technology representative.
 - 6. Submit Manufacturers Extended Warranty Application.

END OF SECTION

SECTION 27 41 17 – SOUND, VIDEO, & COMMUNICATION SYSTEMS

PART 1 – GENERAL

1.1 GENERAL REQUIREMENTS

- A. Work of this Section, as shown or specified, shall be in accordance with the requirements of the Contract Documents.

1.2 WORK INCLUDED

- A. The Sound, Video & Communication System Contractor (SVCC) shall be responsible for all labor, equipment, material, and procedures required for the supply, fabrication, installation, commissioning, and warranty of the Sound, Video & Communication System (SVC) specified herein and on the SVC Contract Drawings, including design and engineering responsibilities, and submission for review of shop drawings, reports, samples, and mock-ups. Detailed descriptions of these requirements are included in “Part 1 - General” and “Part 3 - Execution”.
- B. Requirements Included:
1. The scope of work of this Section shall include, but not necessarily be limited to, the following systems, equipment, material, arrangements, and procedures as indicated and specified herein for:
 - a. All labor, equipment and materials.
 - b. Supply nonstandard back boxes and floor boxes for installation by Electrical Contractor except where noted.
 - c. Termination of all SVC equipment racks.
 - d. Provide supplemental conduit, junction/pull boxes, fittings, and electrical hardware, as required for connection of Sound equipment to the Sound empty conduit system as supplied by Electrical division.
 - e. All wire, wire pulling, and termination.
 - f. All tools and measuring & testing equipment required for installation.
 - g. Daily and final cleanup.
 - h. Shop drawings, samples and mock ups, as built documentation, and operating manual.
 - i. Testing and adjustment, interim shop inspection, initial test report, final site inspection, final test report, and demonstration and instruction.
 - j. Guarantee and warranties, and maintenance and service contract.
- C. Sound, Video & Communication System:
1. See detailed description of the following system and specific information about the equipment, components, and material in “Part 2 - Products”:
 - a. Sound, Video & Communication System: Permanent Sound, Video & Communication System, including speech and music reinforcement, archival audio & video recording, music, effects, and prerecorded tracks processing and playback and stage monitor/foldback, utilizing the following subsystems:
 - b. Permanent loudspeaker positions, including rigging points, and cable management.

- c. SVC equipment racks, including appropriate cabinetry.

D. Related Requirements:

- 1. The following systems, equipment, material, arrangements, and procedures are not included in the scope of work of this Section. Coordinate all work of this Section with the work specified in other sections (exceptions as noted):
 - a. A complete, pull-ready conduit system for installation of Sound, Video & Communication System wiring and devices—including all conduit and raceway, junction/pull boxes, standard back boxes, terminal cabinets and “pull group” boxes, fittings, drag line (pull line), electrical hardware, etc. (Electrical Contractor).
 - b. Electrical power service—including transformers, feeder cable, distribution panels, branch circuit panelboards, and individual wall receptacles (Electrical Contractor).
 - c. Sound, Video & Communication System “Sound, Video & Communication System” isolated ground AC power network (Electrical Contractor). Note: in-rack AC power wiring, shall be the responsibility of the SC. Single point termination to the racks shall be conducted on-site by the EC.
 - d. Loudspeaker suspension points
 - e. Equipment rack room (including lighting, furnishings and finishes, various Trades).
 - f. Painting and finishing (except as noted below for Sound, Video & Communication System equipment).
 - g. House telephone, data, life safety, fire alarm, and security systems (Electrical Contractor).

E. Definitions

- 1. In addition to the definitions in the General Conditions, the following also apply to this Section:
 - a. The term “Consultant” refers to Stages Consultants.
 - b. The terms “Sound, Video & Communication System Contractor”, “this Contractor”, “SVCC” as used in this specification refer to that contractor directly responsible for supply and installation of the Sound, Video & Communication System.
 - c. The terms “engineer” and “engineering” as used in this specification refers to the interpretation, organization, and execution of the design of the Sound, Video & Communication System as provided in the Contract Documents.
 - d. The term “supply” as used in this specification indicates that the Sound, Video & Communication System Contractor shall supply, free issue, including instruction and supervision for installation by others, such equipment, components, and material of the Sound, Video & Communication System so as to fulfill the intent of the Contract Documents.
 - e. The term “provide” as used in this specification indicates that the Sound, Video & Communication System Contractor shall supply, fabricate, install, and make operable such equipment, components, and material of the Sound, Video & Communication System so as to fulfill the intent of the Contract Documents. The terms “preapproved equivalent” and “or as approved” as used in this specification indicate that acceptance shall be obtained from the Consultant. Refer to “Product Substitution” below.
 - g. The terms “NIC” or “not in contract” as used in this specification indicate an item or system that shall be furnished under another contract. Preparation for the future

inclusion of such an item or system shall be limited to the extent outlined in the Contract Documents.

- h. The terms "OEM" or "original equipment manufacturer" or "manufacturer" as used in this specification refer to a direct supplier to the Sound, Video & Communication System Contractor.
- i. "UON" denotes "unless otherwise noted."
- j. "AFF" denotes "above finished floor."
- k. "U" denotes "rack unit," as in "10U" to denote 10 standard 44mm (1.75") rack units, for a total of 440mm (17.5") of rack space.

1.3 SOUND, VIDEO & COMMUNICATION SYSTEM CONTRACTOR

A. Sound, Video & Communication System Contractor Qualification:

- 1. Contractors wishing to qualify for this project shall submit the following information:
 - a. Indicate the names of primary stock holders (in excess of 33-1/3%), and individuals, partnerships, or corporations with which the firm is currently affiliated in joint ventures.
 - b. List the principal officers, design and service engineers, and project managers. Provide an organizational structure flow chart.
 - c. Provide descriptions of Three (3) projects of comparable size, scope and nature for which the candidate has provided full services within the last five (5) years. These services should include: project management, system engineering, shop drawings, custom fabrication, installation, commissioning, training, and maintenance. For each project indicate the specifics of the scope of engineering, fabrication, and installation. Include name, address, and phone number of the owner, architect, Sound, Video & Communication System consultant, and the person(s) directly responsible for the operation and maintenance of the equipment in each facility.
 - d. List all current projects and their approximate contract value. Include name, address, and phone number of the owner, owner's representative, Sound, Video & Communication System consultant, and architect. For each project name the individual(s) who supervised the project management, system engineering, preparation of shop drawings, fabrication of components, installation of equipment, acceptance testing, and commissioning and training.

B. Contractor Submittals

- 1. All contractors shall submit two (2) copies of the following lists, schedules, and bills of material, including the names of manufacturers, manufacturers' model numbers, quantities, and prices:
 - a. Complete pricing information including base price, add-alternates, and unit prices.
 - b. A complete and accurate list of all of the equipment, components, and material specified in the Contract Documents.
 - c. A schedule of wire and cable as specified in the Contract Documents.
 - d. A list of requests for approval of equivalent equipment, components, material, or systems, per the requirements listed in "Product Substitution" below.
 - e. A list of test equipment to be used in system testing and adjustment, per the requirements listed in "Part 3 Execution: Testing and Adjustment."
 - f. A list and description of any equipment or material required for completion of this Section that is not included in the Contract Documents and is not shown on the Architectural or Electrical Contract Documents as being specified by other sections.

- g. A list and description of any changes required to the installation of the empty conduit system, including but not limited to relocation or resizing or reduced or additional conduit, for Sound, Video & Communication System equipment provided by the Electrical Contractor.
- h. A separate cost amount, per year, for a maintenance and service contract for a period of five (5) years. Include a complete description of services to be furnished and a schedule of planned maintenance visits. When the Sound, Video & Communication System Contract is awarded, the Contractor shall be obligated to furnish the services described, for the fees quoted, should the Owner elect to purchase this separate contract prior to the end of the Guarantee and Warranty period. Refer to "Maintenance and Service Contract" below.
- i. In the event that additional conduit is required to fulfill the intent of the Sound, Video & Communication System, the contractor shall include any additional wire.
- j. Any financial or scheduling implications for additional work specified in other sections, as recommended by a contractor, shall be assessed prior to award of this Section.

C. Consultant Review

- 1. The Consultant shall refer to the lists, schedules, and bills of material outlined above in order to determine fulfillment of the requirements of the Contract Documents. These lists, schedules, and bills of material are included for the purpose of evaluation. The acceptance these submissions shall not be understood to relieve the Contractor of the responsibility of meeting any and all requirements of the Contract Documents.

D. Product Substitution

- 1. If an original equipment manufacturer or other supplier permanently stopped fabrication of a specified item or has replaced an item with an almost identical item that has a new model number, the Contractor shall state this or, if there is sufficient time for amendment of the Contract Documents, notify the Consultant.
- 2. Contractors are advised that requests for approval of equivalent equipment, components, and material of other OEM's or suppliers are permitted. Such products shall be evaluated on the basis of equivalent quality and performance. The Consultant shall be the sole judge of performance equivalence and shall give written approval, by addendum, of all product substitutions. Provide sufficient catalog data, specifications, technical information, and samples to permit a complete evaluation by the Consultant.
- 3. While the equipment, material, arrangements, and procedures described in the Contract Documents indicate specific details for realization of the Sound, Video & Communication System, contractors may propose alternate products and details that shall fulfill the functional parameters of the outlined system. In such event, contractors shall submit a complete set of alternate Contract Documents not less detailed than these and following the same general format. Also submit a detailed statement indicating, paragraph by paragraph, where the equipment, material, arrangements, and procedures that shall be offered differ from those specified in the original Contract Documents.
- 4. Any changes to the original Contract Documents shall be evaluated and given written approval by the Consultant.

E. Responsibilities

- 1. Provide complete and working Sound, Video & Communication System as outlined in the Contract Documents.
- 2. Carry out work in accordance with best trade practices, and engineer, fabricate, provide and install all items in accordance with the Contract Documents, the manufacturers'

recommendations and in compliance with applicable codes, and consult with other trades performing adjoining work in order to provide an installation of first class quality.

F. Extent

1. Provide all labor, equipment, material, and procedures required, listed, scheduled, mentioned, or implied in the Contract Documents to engineer, fabricate, install, and commission the Sound, Video & Communication System.
2. Provide also all labor, equipment, material, and any necessary incidental items not specifically called for in the Contract Documents but required for a complete and satisfactory installation of the Sound, Video & Communication System.
3. Ensure that all equipment, components, and material specified or otherwise required to complete the installation are compatible with each other and with the conditions of expected use. Any errors, omissions or ambiguities in the Contract Documents are not to condition these requirements but shall be brought to the attention of the General Contractor and Consultant for evaluation of any possible effect on the intent of the Contract Documents. Submit all notifications in writing to the General Contractor and Consultant. Lack of such notification shall be understood to indicate acceptance of all requirements of the Contract Documents, and any future claims shall be rejected.

G. Coordination

1. Refer to the Project Electrical Drawings, to determine Sound, Video & Communication System device quantities and general locations. Refer to Project Architectural drawings for exact device locations.
2. Be familiar with the requirements of the Electrical Contract to ensure the coordination of the work in this Section with the work of the Electrical Contractor.
3. Provide the Electrical Contractor with drawings, diagrams, and other information in order to ensure proper coordination of the AC power system and Sound, Video & Communication System empty conduit installations. This work shall be part of this Contractor's early coordination effort and shall be provided in a timely manner according to a schedule of the project established by the General Contractor.
4. Coordinate work of this Section with the work of other trades so that all installations are executed in such a manner as to ensure proper system performance. Provide appropriate mounting of equipment and components and avoid conflicts in positioning of the various installations of other contractors and trades.
5. References to the General Contractor or other trades shall in no way modify the responsibility of the Contractor to provide a coordinated, complete, and working installation of all work required by the Contract Documents.
6. All drawings, schedules, RFIs, and other communication shall be coordinated with and submitted through the General Contractor.

H. Means and Methods

1. The Sound, Video & Communication System Contractor is solely responsible for the means and methods of all manufacturing and installation techniques, sequences and procedures of construction, and shall be responsible for coordination of these items with and through the General Contractor and the Consultant.

I. Sub-Contractors

1. Use of Sub-Contractors by the Sound, Video & Communication System Contractor shall in no way modify its responsibility.

J. Suppliers

1. Use of a product from a particular original equipment manufacturer, whether specified in the Contract Documents or substituted by the Sound, Video & Communication System Contractor, shall in no way modify its responsibility. Refer also to General Conditions.
- K. Site Dimensions and Conditions
1. The Sound, Video & Communication System Contractor is solely responsible for the correctness of dimensions and quantities, shall verify site conditions, and obtain site dimensions and quantities required for proper installation of the work included in this Section; and shall be responsible for coordination of these with and through the General Contractor. The Sound, Video & Communication System Contractor shall take dimensions on site for all equipment and material that shall be provided (including custom fabricated components) and be entirely responsible for their accuracy.
 2. Examine the work of other trades at the site to ensure that all aspects of the related work are in the proper condition to receive the work included in this Section.
 3. Obtain through the General Contractor, where necessary, copies of relevant base building Contract Documents, including shop drawings, to ascertain existing field conditions not open to view (e.g., wall or ceiling construction).
 4. In particular, verify all necessary field conditions including, but not limited to: the size, routing, and location of all conduit and raceway, pull/junction boxes, cast-in-place back boxes, and accommodation of non-standard backboxes. Also verify size and configuration of the Equipment Rack Room. Such information is critical to the production of accurate shop drawings.
 5. Provide any additional drawings, information, or templates where work by other trades must be modified for the proper installation and operation of the work included in this Section.
 6. Do not begin manufacture of any custom fabricated equipment or components until satisfied that the devices, as designed, shall fit in the space available.
 7. Provide all additional items required for the completion of the Sound empty conduit system, as supplied by the Electrical Contractor including but not necessarily limited to conduit hardware, back boxes, and wire to accommodate site conditions, and in order to complete the interpretation of the Contract Documents with no change in the contract price. Any changes to equipment details and/or mounting details shall be reviewed and approved by the General Contractor and Consultant prior to shop fabrication or field installation.
- L. Design and Engineering
1. The requirements outlined in the Contract Documents establish basic design parameters including means of operation, control, dimensions, and visual appearance. The Sound, Video & Communication System Contractor's design responsibilities shall include:
 2. Interpreting the Contract Documents so as to accomplish the purposes described.
 3. Carrying out the execution of the work.
 4. Executing modifications and additions to the details as may be required to fulfill the intent of the Contract Documents.
 5. Maintaining the design/control/operation concepts as described in the Contract Documents.
 6. The Contract Documents describe performance attributes of the systems that shall be provided under this Section and, as such, are not Professionally Engineered documents. This Contractor is responsible for the engineering of systems described in the Contract Documents.
- M. Painting and Touch Up

1. The Sound, Video & Communication System Contractor shall be responsible for painting all Sound, Video & Communication System equipment and components exposed to view and shall also be responsible for the correction of minor cosmetic damage so that all Sound, Video & Communication System equipment and components are in clean and unblemished condition at the time of the final site inspection by the Owner and Consultant.
2. Any non-cosmetic damage shall be promptly repaired or replaced by this Contractor, prior to the final site inspection and without cost to the Owner.

N. Cleanup

1. Leave work areas clean and in proper order at the end of each work day. Coordinate with Owner's performance and rehearsal schedule, as required. Daily and final cleanup shall be to the satisfaction of the General Contractor and/or the Owner.

O. Omissions And/Or Errors

1. Omissions and/or errors within the Contract Documents shall not relieve the Contractor of the responsibility for providing a properly functioning installation of the Sound, Video & Communication System as outlined in "Part 2 - Products: System Description".

P. Permits

1. Obtain all permits and pay all fees necessary for the execution of the work included in this Section.

Q. Safety and Code Requirements

1. The Sound, Video & Communication System equipment, material, arrangements, and procedures shall conform to the applicable local building, electrical and safety codes and all other applicable code requirements, industry standards of operation and practice, and applicable safety requirements. The completed installation shall allow the users to work and operate the Sound, Video & Communication System in a safe environment.
2. Regulations, codes of practice, and other reference documents cited in the Contract Documents shall apply to the work of this Section with the same authority as if included word for word in this specification.
3. Where provisions of the Contract Documents supplement those of cited reference documents, the more stringent provisions shall apply. Refer also to General Conditions.

1.4 SUBMITTALS

A. Project Timetable:

1. Submit a Sound, Video & Communication System project timetable for approval, after consultation with the General Contractor and the Consultant.
2. This timetable shall outline scheduling and dates for all project milestones including design and engineering, shop drawing submittal and review, sample and mock-up submittal and approval, shop fabrication, interim shop inspection, site installation, testing and adjustment, initial test report submittal and approval, final site inspection, programming, final test report submittal and approval, operating manual and as-built documentation submittal and approval, demonstration and instruction, and project completion.

- B. Pre-Submittal Meeting:
1. The Sound, Video & Communication System Contractor shall meet with the General Contractor and the Consultant after the project timetable has been submitted and prior to beginning work on shop drawings. The project manager and chief project designer for the Sound, Video & Communication System Contractor must attend and be prepared to review the timetable, and to discuss the concepts described in the Contract Documents and proposed methods of execution of those concepts.
- C. Shop Drawings:
1. Submit, through the General Contractor, shop drawings for submittal to the Consultant. Shop drawings shall include all information necessary to fully explain design features, engineering details, appearance, function, fabrication, mounting, installation, and interconnection of all equipment. This submittal shall include the following:
 - a. Block diagrams (indicating all equipment interconnection and wiring).
 - b. Schematic diagrams of custom circuitry and equipment.
 - c. Equipment rack layouts.
 - d. Custom receptacle plate, combination panel, and communication control pendant layouts (full scale drawings required).
 - e. Custom mounting brackets.
 - f. Mounting conditions and methods for all devices.
 - g. Wiring distribution diagrams and wire pulling schedules.
 - h. Detail drawings as required.
 2. Submit names of the original equipment manufacturers or other suppliers, the specific model numbers of all Sound, Video & Communication System components, appropriate OEM catalog sheets, and technical data sheets. Submit also detailed descriptions of any required modifications to the specified equipment.
 3. Submit a complete, itemized list of all equipment and material that shall be provided as part of the Sound, Video & Communication System. All equipment and material shall be listed by the same name, and in the same order as it appears in "Part 2 - Products." Submit also similar lists for the portable equipment, spare parts, and test equipment to be supplied.
 4. Shop drawings shall represent actual fabrication and installation details. Information on all shop drawings shall be designed, engineered, and drafted by this Contractor. Direct reproductions of contract drawings are not acceptable as shop drawings and shall be rejected.
 5. Provide shop drawings separated into the various systems, where each set of drawings contains that information necessary to describe each system completely. The shop drawing submittal shall also include a fully referenced table of contents.
 6. Consultant Review:
 - a. The shop drawings shall be reviewed by the Consultant and shall be approved before the Sound, Video & Communication System Contractor begins fabrication and installation of any aspect of the Sound, Video & Communication System. Note that the review of shop drawings by the Consultant is to determine conformance with the design concept and with information included in the Contract Documents. Only those shop drawings returned to this Contractor with a satisfactory review status shall be used in the execution of this Section. Non-conformities and errors detected during the shop drawing review shall be noted on the drawings and returned to the Sound, Video & Communication System Contractor upon completion of the review. The Contractor is responsible for the completeness and accuracy of the shop drawings.

- b. Shop drawings or packages of shop drawings that are incomplete shall be marked “rejected” until such time as the complete set of relevant drawings is submitted. It is impossible for the Consultant to adequately review technical equipment submissions unless all details have been adequately represented.
 - c. Approval of those shop drawings that include any non-conformities or errors that are not detected during the Consultant’s review shall not relieve this Contractor of the sole responsibility to provide an installation adhering strictly to the requirements of the Contract Documents.
 - d. Shop drawing review does not include engineering calculations by the Consultant unless expressly indicated on the drawings.
- D. Samples And Mock-Ups:
1. After review of appropriate shop drawings, submit one (1) sample each of the following items, clearly labeled with manufacturer name, model number, and other pertinent data, for approval by the Consultant:
 2. All cloth and/or metal grille material, with integral framing or support construction where appropriate.
 3. Custom paint samples for Sound, Video & Communication System devices requiring a change in color from that supplied by the manufacturer. Each sample shall be applied to a 150mm x 150mm (6” x 6”) piece of material closely matching the surface characteristics of each device type to be painted. On the back of each sample indicate the painting system, type of paint for each coat (including primer), the color and sheen of the finish coat, and description of the item(s) and location(s) where the color on the paint sample will be used.
- E. Record Drawings:
1. Keep a complete set of white prints of the specification and all contract drawings for this Section of the work, as well as shop and installation drawings. Any changes made during installation should be carefully noted and transferred to the appropriate documents to show “as-installed” work in accordance with Section 1, Submittals.
 2. At the time of the initial test report submission, submit one (1) corrected set of record drawings and shop/installation drawings for review by the Consultant.
 3. Late changes or adjustments performed as corrections to punch list items or as change orders after practical completion of the contract, shall be reflected on updated record drawings by the Contractor.
 4. After review by the Consultant, make any required revisions to the record drawings until the contents are satisfactory to the Consultant.
- F. Operating Manual:
1. Provide one (1) copy of operating manuals in accordance with Section 1, Submittals. Mark each section with tabular dividers using permanent labels protected by plastic. All drawings (8 1/2 size and larger) shall be folded into individual vinyl pockets (sheet protectors). Include the following items:
 - a. Title sheet labeled “Sound, Video & Communication System—Operating Manual”, project name, and date.
 - b. Table of contents.
 - c. Names, addresses, and phone numbers of Sound, Video & Communication System Contractor, sub-Contractors, and suppliers.
 - d. Final version of the equipment list.
 - e. System description.
 - f. Operating instructions.

- g. Periodic maintenance procedures.
 - h. List of all spare parts and equipment.
 - i. Complete OEM data sheets, operating manuals, service manuals, and related documentation.
 - j. Block and schematic diagrams of all systems.
 - k. Plugging key plan, showing wiring and receptacles (i.e., a quick-reference chart of combination panels, wall receptacles, and patching only).
 - l. Device, wiring, termination, and hardware schedules.
 - m. List of equipment design parameters including safe working capacities, maximum simultaneous operations, and similar information.
 - n. Maintenance instructions for finished surfaces and material.
 - o. Record of performance (Final Test Report data) as demonstrated at final site inspection sessions.
2. Prepare one (1) draft copy of the Operating Manual for review by the Consultant four (4) weeks prior to the final site inspection. The document shall be clearly marked "FOR REVIEW." After review by the Consultant, make any required revisions to the Operating Manual until the contents are satisfactory to the Consultant.

G. Mounted Block Diagram:

1. Provide prints of each Sound, Video & Communication System block diagram in the equipment rack room. Mount each diagram in a poster frame and securely mount in each control/rack room adjacent to the equipment racks. Block diagrams shall be of approved record drawings.

1.5 COMMISSIONING

A. Testing and Adjustment:

1. Perform tests and adjustments to the Sound, Video & Communication System at the project milestones indicated below, and as specifically outlined in "Part 3 - Execution: Testing and Adjustment."

B. Interim Shop Inspection:

1. Test and demonstrate the function of all systems, equipment, assemblies, and subassemblies of the Sound, Video & Communication System in the shop or factory no later than Six (6) weeks prior to project completion. Provide all test equipment, and perform all tests and demonstrations in the presence of the Consultant. The systems, equipment, and components that shall be tested and demonstrated include, but are not necessarily limited to, the following:
 - a. Sound, Video & Communication System equipment, including playback computer, signal processing racks, amplification and loudspeakers.
 - b. Notify the Consultant at least three (3) weeks prior to the date when all systems, equipment, assemblies, and subassemblies are complete and ready for testing. The equipment shall be made available to the Consultant for a period of at least one (1) week for testing and inspection prior to shipment. Do not ship any piece of equipment without either written verification of successful shop testing, or waiver of shop testing from the Consultant.
 - c. Prepare a draft of the initial test report (outlined below), indicating all pre-installation or shop testing, and submit the report to the Consultant for review prior to shipment of equipment from this Contractor's shop.

- C. Initial Test Report:
1. Perform all testing outlined in this specification. This shall occur after substantial performance of the Sound, Video & Communication System, and before scheduling the final site inspection.
 2. Submit a complete report on the results of all testing and adjustments for review by the Consultant, and also certify, in writing, that the work of this Section is complete, operational in every respect, and that the Sound, Video & Communication System are ready for the final site inspection.
- D. Final Site Inspection:
1. Upon approval of the initial test report, the Sound, Video & Communication System Contractor shall notify the General Contractor and Consultant, in writing, and schedule the final site inspection for a time no later than four (4) weeks prior to the scheduled substantial completion of the project. During this inspection demonstrate all the items described in this specification, and be prepared to demonstrate the operation of any of all portions of the Sound, Video & Communication System, as requested by the Consultant.
 2. Furnish sufficient technicians to operate all equipment and to perform such tests and adjustments as may be required by the Consultant during this inspection. Provide also sufficient engineering and field service personnel to aid the Owner and Consultant, and to direct the technicians in testing, adjusting, and explaining the systems. Ensure that ladders and other means are provided to allow access to all devices to be tested. Ensure that no other work is scheduled in the audience chamber or stage areas during the time of this inspection. All temporary bracing, scaffolding, etc., shall be removed to permit full operation of, and access to, all equipment.
 3. Should the work inspected not be substantially performed at the time of first inspection, this Contractor shall compensate the Owner for any consulting and transportation costs incurred by the Owner and Consultant during all inspections.
 4. If the system does not fulfill each and every aspect of the Contract Documents, make all necessary adjustments or other required changes in order to bring the installation into conformance with the Contract Documents at no additional cost to the Owner.
- E. Installed System Measurement, Verification and Optimization:
1. Upon completion of the Final Test procedure, proceed with the comprehensive complex measurement of the electroacoustic performance of the various components of the performance-related sound equipment. This testing procedure includes all of the signal path leading up to and through the loudspeaker systems and their processors. This contractor shall provide a SMAART measurement system and will have subcontracted a Consultant-approved SMAART operator who will conduct the actual measurements and supervise the optimization of these systems. This measurement process shall be scheduled for a period of two (2) consecutive days. Ensure that no other work is scheduled in the ride area during the time of this procedure. All temporary bracing, scaffolding, etc., shall be removed to permit full operation of, and access to, all equipment.
 2. Furnish sufficient technicians to help operate all Sound, Video & Communication System equipment and to perform the various corrective tasks that are revealed during this procedure, including rigging adjustments and polarity correction. Provide all required support equipment such as computer monitors, keyboards, two-way radios, etc. Ensure that ladders and other means are provided to allow access to all devices to be tested.
- F. Programming:

1. Following completion of System Optimization, the Consultant and Project creative team will undertake a two-week Ride programming period. Contractor shall provide full technical personnel support during this process.
- G. Final Test Report:
1. After completion of the final site inspection and system optimization, submit a final version of the complete report on all testing and adjustment outlined in this specification for review by the Consultant. The final test report shall be accompanied by a letter certifying that the Sound, Video & Communication System conform to the Contract Documents, that the installation is complete in all details, that the final site inspection is complete and successful, that the system optimization is complete in all details and that the system ready to be turned over to the Owner. Include printouts of SIM II measurement plots showing pre and post optimization.
- H. Demonstration And Instruction:
1. Instruct the Owner and/or the facility's operating personnel in the operation and care of the systems during two (2) separate sessions for not less than a total of eight (8) hours. This instruction shall include:
 2. Operating procedures for proper use of all systems.
 3. Proper maintenance of all systems.
 4. Replacement procedures for user replaceable parts.
 5. The first demonstration and instruction session shall occur directly after acceptance of the final test report. The second session shall occur at a time arranged by the Owner and/or the facility's operating personnel, and shall be no sooner than the next day and no later than one (1) month afterwards. The precise timing of these sessions shall be determined by the Owner, at the Owner's convenience. The sessions shall be videotaped by this Contractor on portable video equipment. A dvd of the recorded session shall be submitted to the Owner within one (1) week following the taping.
 6. As a portion of this instruction, present the final approved, version of the Operating Manual to the Owner, General Contractor and Consultant for preview at least two (2) weeks prior to the first instruction session. Review the contents of the Operating Manual with the Owner and/or the facility's operating personnel as part of the first session.
- I. Guarantee And Warranties.
1. Furnish the Owner with a written guarantee in accordance with General Conditions, covering all engineering, equipment, material, and installation workmanship incorporated into the work of this section, until one (1) year after date of substantial completion of the project.
 2. Service Calls
 - a. All guarantee and warranty work shall be carried out at no additional cost to the Owner for any labor, parts, shipping or transportation. Warranty replacement equipment shall be provided within 24 hours of official notice by the Owner.
 3. Equipment Warranties
 - a. Warranty of replacement equipment and components shall be the same as for the original devices, and shall begin on the date of installation of the replacement item. Replace spare parts used during the warranty period at no additional cost. Note all such replacement equipment and components in a written report to the Owner and the Consultant, and in an addendum to the Operating Manual.
 - b. In the absence of a maintenance and service contract (outlined below), honor all extended warranties offered by original equipment manufacturers beyond the one (1) year guarantee outlined above. The Sound, Video & Communication System

- Contractor shall not be responsible for any labor, transportation, shipping, or miscellaneous costs not covered by the OEM incurred during service calls to repair or replace extended warranty equipment.
4. Follow-Up Testing and Adjustment
 - a. Provide technicians to test and adjust the Sound, Video & Communication System, at a mutually agreed upon time, approximately six (6) months after substantial completion of the project. This follow-up visit shall include any needed testing and repair of all items covered under the guarantee, and testing and readjustment of all items identified in the maintenance procedures. Provide a written report to the Owner and Consultant outlining the extent and results of the follow-up testing and adjustment.
 5. Repeated Failures
 - a. If a particular component, part, or piece of equipment fails more than three times during the warranty period, the failure shall be deemed to be due to engineering and/or installation error. In this event take action within 24 hours of official notice by the Owner to modify or correct the defect by replacement of faulty equipment and/or changes to engineering concepts or installation methods.
- J. Maintenance and Service Contract:
1. In addition to providing guarantee and warranty service, make available to the Owner a separate service contract to begin after expiration of the guarantee and warranties outlined above. The service contract shall be at the Owner's cost, renewable yearly, and available for the life of the Sound, Video & Communication System. This service contract may be provided directly by this Contractor or through an approved local or regional service center.
 2. The service contract shall cover every item provided and supplied under this section of the contract. Service offered shall include, but not necessarily be limited to, repair of components, temporary equipment, replacement of parts, and a regular maintenance program for all equipment in the Sound, Video & Communication System. The service contract shall specify a guaranteed response time.

PART 2 – PRODUCTS

	<i>description</i>	<i>mfr</i>	<i>model</i>	<i>qty</i>
AUDITORIUM				
A	Mixing System / Playback			
1	F-XLR Stage Boxes to M-XLR Tails, 12ch , 50'	Whirlwind	ME-12-M-NR-50	1
2	Digital Mixing Console System, 48kHz,	Yamaha	QL1	1
3	Console Rack	Yamaha	RK1	1
4	Console Gooseneck Lamp	Yamaha	LA1L	1
5	Console fixed format I/O, 32 Analog ip, 16 Analog op, 4 AES op	Yamaha	Rio3224-D2	1
6	Console fixed format I/O, 16 Analog ip, 8 Analog op	Yamaha	Rio1608-D2	1
7	16U Portable Rack w/ Mixer Rails	Audiopile	C16U-P-22M	1

	<i>description</i>	<i>mfr</i>	<i>model</i>	<i>qty</i>
8	Rack Mount power Conditioner	Furman	PL-PRO C	1
9	3U Rack Drawer w/ Lock	MiddleAtlantic	TD3LK	2
10	2U Rack for Rio1608	Gator	G-Tour 2U	1
11	Rack Mounted Analog Mixerv w/ Bluetooth	Alesis	Multi-Mix 10	1
12	iPad Air, 64GB, WiFi, w/ Smart Folio	Apple	iPad Air 64GB WiFi	1
13	WiFi Router	Netgear	R6700 AC1750	1
B	<i>Main Loudspeaker System - Auditorium</i>			
1	Center Loudspeaker Upper	d&b audiotechnik	Yi7P	1
2	Horizontal Bracket for Yi7P	d&b audiotechnik	Z5398	1
3	Center Loudspeaker Lower	d&b audiotechnik	E12-D	1
4	Horizontal Bracket for E12-D	d&b audiotechnik	Z5353	1
5	Center Loudspeaker Outer Fill	d&b audiotechnik	E6	2
6	Horizontal Bracket for E6	d&b audiotechnik	Z5351	2
7	Proscenium Side Loudspeaker	d&b audiotechnik	E12-D	2
8	Prosc Side Loudspeaker Flying Adapter	d&b audiotechnik	Z5352	2
9	Backstage Foldback Loudspeaker	d&b audiotechnik	5S	4
10	Backstage Foldback Loudspeaker Brkt	d&b audiotechnik	Z5422	4
11	Custom #12 NL2 Cables for Permanent Loudspeakers	Whirlwind	\$300 Allowance	1
12	Miscellaneous Rigging Materials incl Safeties for all Loudspeakers		\$2500 Allowance	1
13	4-Ch Power Amplifier w/ DSP Processing	d&b audiotechnik	40D	1
14	4-Ch Power Amplifier w/ DSP Processing	d&b audiotechnik	10D	1
C	<i>Self-powered Portable Monitor/Effects Loudspeakers</i>			
1	Self-powered Monitor Loudspeaker Large	Electro-Voice	PXM-12MP	2
2	Self-powered Subwoofer	TurboSound	iNSPIRE iP12B	2
3	50' AC Cable for Self-powered Loudspeakers	Lex	PE700-50-515	4
D	<i>Wireless Microphones</i>			
1	UHF Digital Combo Wireless Mic System Recvr/Handheld/Bodypack	Sennheiser	EW-D ME2/835-S SET (Q1-6)	4
2	Passive Directional Paddle Antenna	Sennheiser	ADP UHF	2
3	Active Antenna Splitter for 4 Receivers, incl PSU	Sennheiser	EW-D ASA (Q-R-S)	1
4	Rechargeable Battery Pack for Handheld & Bodypack Tx	Sennheiser	BA70	4
5	EW-D Charging Set, incl. L-70 charger and 2 BA70 batteries	Sennheiser	EW-D Charging Set	2
6	Miscellaneous Rigging Materials for Antenna Mounting	Sennheiser	\$200 Allowance	1

	<i>description</i>	<i>mfr</i>	<i>model</i>	<i>qty</i>
E	<i>Wired Microphones & Direct Boxes</i>			
1	Handheld, dynamic Microphone	Shure	SM-58LC	5
2	Handheld, dynamic Microphone w/switch	Shure	SM-58S	1
3	Dynamic Instrument Microphone	Shure	SM-57LC	2
4	Condenser Instrument Microphone, cardioid	Shure	SM-81LC	2
5	Hanging Chorus Microphone	Countryman	isoMax 2H	4
6	Direct Box, Jensen, single-ch	Radial	JDI	2
7	Direct Box, Jensen, PC/iPod	Radial	JPC	1
8	Instrument Cable, 10'	Whirlwind	SN10	2
9	iPod Cable, 3.5mm Stereo>2x M-XLR, 6'	Whirlwind	MST2XM06US	2
F	<i>Microphone Stands</i>			
1	Microphone Stand, Round Base, Black	K&M	260/1	2
2	Microphone Stand, One-hand clutch, stackable, Black	K&M	260/1	6
3	Microphone Stand, Tripod w/ Boom, Black	K&M	260/8	2
4	Microphone Stand, Short, Round Base, w/ Boom, Black	K&M	259/1	1
5	Microphone Boom Arm	K&M	211/1	4
6	Microphone Clamp	K&M	238	2
7	Microphone Holder	K&M	240/5	2
8	Microphone Desk Stand, Black	Atlas	DS7E	4
9	Microphone Stand Crate	Custom	\$500 Allowance	1
G	<i>Portable Microphone Cable</i>			
1	Microphone Cable, Canare/Neutrik, 10'	Whirlwind	MK410NP	4
2	Microphone Cable, Canare/Neutrik, 25'	Whirlwind	MK425NP	8
3	Microphone Cable, Canare/Neutrik, 10'	Whirlwind	MK450NP	8
4	Microphone Cable, Canare/Neutrik, 100'	Whirlwind	MK4100NP	2
H	<i>Assistive Listening System</i>			
1	FM Assistive Listening System, w/transmitter, 4 receivers	Listen	LS-31-072	1
2	Receiver, digital	Listen	LR3200	8
3	Charging case for 12 receivers	Listen	LA-380	
4	Rechargeable battery	Listen	LA-365	12
5	Neck loop for receivers	Listen	LA430	2
6	Ear Buds	Listen	LA-401	12
I	<i>Audio Monitor System</i>			
1	Condenser Recording Microphone, cardioid, Matched Pair	Neumann	KM 184 Stereo Set	1
2	Microphone Mounting Hardware, Allowance	Custom	\$50 Allowance	1
3	Portable Phantom Power Supply	Samson	S-Phantom	2
4	70v Mixer/Amp	Bogen	Classic C20	1
5	70v Mixer/Amp Rack Kit	Bogen	RPK35B	1

	<i>description</i>	<i>mfr</i>	<i>model</i>	<i>qty</i>
6	Surface Mount loudspeaker w/ 70V transformer	Tannoy	DVS4T	2
7	Volume control, 70V, 35W	Atlas Sound	AT35D	2
J	<i>Equipment Rack, Portable Equipment Storage Cabinet</i>			
1	Equipment Rack	MiddleAtlantic	BGR-4532-SA-LRD	2
2	Rack Top, vented	MiddleAtlantic	BGR-LVT	2
3	Rear door, with cable entry	MiddleAtlantic	BGR-RDC45	2
4	Cable Lacer Bars - 10pk	MiddleAtlantic	LBP-1.5	2
5	Vent Panels as Required	MiddleAtlantic	\$100 Allowance	1
6	Blank Panels as Required	MiddleAtlantic	\$100 Allowance	1
7	1sp Brush Panel	Middle Atlantic	BR	2
8	3U Rack Drawer w/ Lock	MiddleAtlantic	TD3LK	2
9	Rack Panel Screws	MiddleAtlantic	HP-500	1
10	TechFlex, 1.25"-2.75" expandable tubing	TechFlex	PET8-50-BK	1
11	Rack Mount power Conditioner	Furman	FC-PRO C	4
12	Internal Rack Work Light	MiddleAtlantic	WL60	2
13	Cable Management, in rack, vertical cable tray	Heileman, equal	2x2, 3x3	1
14	Storage Cabinet w/ 6 Shelves, 48"w x 19"d x 72"h	Master Carr	4775T71	1
15	48port Gigabit Network Switch - AVNet	Hewlett Packard	TBD	1
16	24port Gigabit Network Switch - Dante	Hewlett Packard	TBD	2
17	16port Gigabit Network Switch - Dante	Hewlett Packard	TBD	2
K	<i>Custom Panels, Patch Panels</i>			
1	Custom Panel, laser-etched, black aluminum	WW Custom	C11	1
2	Custom Panel, laser-etched, black aluminum	WW Custom	C12	1
3	Custom Panel, laser-etched, black aluminum	WW Custom	C13	1
4	Custom Panel, laser-etched, black aluminum	WW Custom	C14	1
5	Custom Panel, laser-etched, black aluminum	WW Custom	C15	1
6	Custom Panel, laser-etched, black aluminum	WW Custom	C16	1
7	FloorBox for C16 w/ Cover TBD	FSR	FL-500P-4	1
8	Custom Panel, laser-etched, black aluminum	WW Custom	C17	1
9	Custom Panel, laser-etched, black aluminum	WW Custom	C21	1

10	Custom Panel, laser-etched, black aluminum	WW Custom	C22	1
11	Custom Panel, laser-etched, black aluminum	WW Custom	C23	1
12	Custom Panel, laser-etched, black aluminum	WW Custom	"S1" Receptacles	2
13	Custom Panel, laser-etched, black aluminum	WW Custom	"S2" Receptacles	2
14	Custom Panel, laser-etched, black aluminum	WW Custom	"M2" Receptacles	1
15	Custom Panel, laser-etched, black aluminum	WW Custom	"D2" Receptacles	2
16	Custom Panel, laser-etched, black aluminum	WW Custom	"Mi Patch"	1
17	Custom Panel, laser-etched, black aluminum	WW Custom	"Line Patch"	1
18	Custom Panel, laser-etched, black aluminum	WW Custom	"Speaker Patch"	1
19	Custom Panel, laser-etched, black aluminum	Leviton	"CAT6 Patch"	2
L	Bulk Cable, Pre-Made Cables			
1	A1 - Microphone cable, 1pr - 1000'	Belden	9451	2
2	A2 - Microphone cable, 2pr - 1000'	Belden	1509C	2
3	A4 - Microphone cable, 4pr - 1000'	Belden	1510C	6
4	D3 - 4x23 AWG Twisted Pair, CAT6A SHIELD - 1000'	West Penn	4346AF	10
5	F1 - 2x 12 AWG Stranded Copper w/ PVC Jacket - 1000'	Belden	5000UP	4
6	G1 - 2x 14 AWG Stranded Copper w/ PVC Jacket - 1000'	West Penn	226	1
7	LOT, Pre-made Cables for all Interconnect	Custom	\$2,000 Allowance	1
8	LOT, Pre-made Cables for all Patching	Custom	\$500 Allowance	1
M	SVC-ADD-ALT #1 - Video Projection System (provide breakout pricing for this section)			
1	7000 lms UXC Laser Video Projector	Panasonic	PT-RZ790	1
2	Mount for Projector	TBD	\$500 Allowance	1
3	HDMI/VGA > HDBaseT Transmitter Wall Plate	Atlona	AT-HDVS-150-TX-WP	3
4	HDBaset-to HDMI 8x4 Video Switcher	Atlona	AT-UHD-CLSO-824	1
5	Dual 7" HD Rack Mount Video Monitor	ELVID	SRM-7X2-LT	1
6	CD/BLU-Ray Player	Denon	DN-500BD	1
7	Apple TV; 32GB	Apple	Apple TV	1

	<i>description</i>	<i>mfr</i>	<i>model</i>	<i>qty</i>
8	16:9 Motorised Projection Screen, w/ Backstage, Booth and Control System Controllers	Da-Lite	Arena Electrol 20815	1
9	iPad-based Remote Control Gateway	Kramer	SL-240C	1
10	iPad Control System Programming	Custom	\$3,500 Allowance	1
N	SVC-ADD-ALT #2 - Wireless Intercom System (provide breakout pricing for this section)			
1	1.9 GHz Wireless Intercom System, 8 Users incl. Headsets	Hollyland	SolidCom M1	1
O	SVC-ADD-ALT #4 - Portable Wireless Microphones (provide breakout pricing for this section)			
1	UHF Combo Wireless Mic System Recvr/Bodypack/ MKE2ew Lavalier Mic	Sennheiser	EW-D ME2 35-S SET (Q 6)	6
2	Active Antenna Splitter for 16 Receivers, incl PSU & 2 Antenna	Sennheiser	EW-D ASA (S)	5
3	Passive, directional Paddle Antenna	Sennheiser	ADP UHF	2
4	Rechargeable Battery Pack for Handheld & Bodypack Tx	Sennheiser	BA70	16
5	EW-D Charging Set, incl. L-70 charger and 2 BA70 batteries	Sennheiser	EW-D Charging Set	2
6	Miscellaneous Rigging Materials for Antenna Mounting	Sennheiser	\$500 Allowance	1
7	16U Portable Equipment Rack w/ Power Mod	EWI	R16U	1

NOT FOR BID

PART 3 – EXECUTION

3.1 QUALITY ASSURANCE AND WORKMANSHIP

- A. The Sound, Video & Communication System Contractor shall follow good working practices and fabricate and install items in accordance with the manufacturer's recommendations and the Consultant's specifications. Provide quality control procedures acceptable to the Owner and Consultant. Provide a properly qualified site supervisor who shall carry out supervision duties only. Provide straight, plumb, true and aligned components throughout, and shall consult with other trades doing related work and adjoining work in order to provide an installation of first-class quality.
- B. The Consultant reserves the right to reject any part of the installation not in compliance with the Contract Documents. The Sound, Video & Communication System Contractor shall carry out any necessary remedial work or replacement free of charge and without delay to the Owner.
- C. A standard reference guide for the design, engineering, and installation of the Sound, Video & Communication System shall be Audio System Design and Installation, by Philip Giddings (Sams Publishing).

3.2 DEFINITIONS

- A. Electrical Reference:
 - 1. The following electrical references are used throughout the Sound, Video & Communication System specification:
 - a. Voltage: $\text{dBv} = 20\log(E_1/E_2)$
 - b. Power: $\text{dB} = 10\log(P_1/P_2)$
 - c. $0\text{dBu} = 0.775\text{VRMS}$; ratio of voltages measured open circuit
 - d. $0\text{dBv} = 0.775\text{VRMS}$; ratio of voltages measured open circuit
 - e. $0\text{dBV} = 1.0\text{VRMS}$; ratio of voltages measured open circuit
 - f. $0\text{dBm} = 1\text{mW}$; power level (typically 0.775V into 600-ohm load)
 - g. $0\text{VU} = +4\text{dBm}$; power level referenced to 600 ohms
- B. Electrical Characteristics:
 - 1. Unless otherwise specified in the Contract Documents, electrical characteristics of the Sound, Video & Communication System equipment shall be as follows:
 - a. Microphone preamplifier inputs shall be balanced, have an impedance greater than or equal to 1.2k ohms , and designed to be driven from sources of 600 ohms or less.
 - b. Line inputs shall be balanced bridging, have an impedance greater than or equal to 10k ohms , and designed to be driven from sources of 10k ohms or less.
 - c. Line outputs shall be balanced, have an impedance less than or equal to 100 ohms , and designed to drive loads of 600 ohms or greater.
- C. Connector Polarity: Proper polarity of connectors on combination panels, receptacle plates, rack panels, patch panels, and other devices fabricated and/or wired by this Contractor shall be established as follows: Polarity of connectors for OEM devices and equipment may be different, and should be wired to patch panels so as to maintain consistent system polarity.

1. Microphone and Line Level
 - a. Balanced Connection

XLR-3 connectors: pin 1 = ground/shield (do not connect to case); pin 2 = high (“hot”); and pin 3 = low (“cold”).

¼” T/R/S phone connectors: sleeve = ground/shield; ring = low (“cold”); and tip = high (“hot”).

- b. Unbalanced Connection

XLR-3 connectors: pin 1 = ground/common/shield (do not connect to case); pin 2 = high (“hot”); and pin 3 = tie to pin 1 only.

¼” T/S phone connectors: sleeve = ground/common/shield; and tip = high (“hot”).

Phono (RCA) connectors: sleeve or shell = ground/common/shield; and center pin = high (“hot”).

2. Multiconductor Application

- a. Multipin connectors: Refer to the manufacturer’s specifications.

3. Data Connection

- a. RJ45 connectors: Refer to the manufacturer’s specifications.

4. Video and RF Level

- a. BNC-type connectors: sleeve or collar = ground/shield; and center pin = signal (“hot”).

5. Low Impedance Loudspeaker Level

- a. Neutrik NL4 series connectors used for unamplified or passive (mono-amplified) Sound, Video & Communication System loudspeakers: pin “1+” = Low frequency or full-range driver “+”; pin “1-” = Low frequency or full-range driver “-”; pin “2+” = High frequency driver “+”; pin “2-” = High frequency driver “-”.

- b. Neutrik NL4 series connector used for 70.7 volt lines: pin “1+” = high (“hot”); pin “1-” = N/C; pin “2+” = N/C; and pin “2-” = low (“common”).

- D. Transducer Polarity: Proper polarity of electro-acoustic transducers shall be established as follows, with exceptions as noted:

1. Microphone

- a. Positive acoustic pressure on the microphone diaphragm produces a positive voltage on pin 1 with respect to pin 3 of the output connector.

2. Loudspeaker

- a. Positive voltage applied to the (+) terminal produces a displacement of the loudspeaker cone away from the magnet, thus producing a positive acoustic pressure.

3.3 INSTALLATION

- A. General

1. All equipment except portable equipment shall be securely held in place with a safety factor of at least three; except that all equipment rigged overhead shall be so done using safe rigging practices and with rated hardware selected to meet a safety factor of at least ten. All equipment shall be installed in such a fashion as to present no safety hazard to operating personnel.

2. All equipment shall be adequately ventilated when operating under worst-case power dissipation.
3. All metal cabinets connected to the Sound, Video & Communication System audio ground network shall be effectively isolated from any conduit or other metallic component that is connected to the building electrical safety ground.
4. All installation work shall be carried out in a neat and orderly fashion.

B. Wiring:

1. Ensure by drawing review and field survey that the conduit/raceway infrastructure is sufficient for the proper installation of the specified and required wire and cable, and/or any approved-substitute types of wire and cable.
2. Do not begin pulling Sound, Video & Communication System wiring through the Sound, Video & Communication System Empty Conduit System until all conduit, pull boxes, etc. for each given run (point-to-point) are completely installed by the Electrical Contractor and ready for such wire and cable installation. Undertake a field inspection of the conduit system and pull boxes, reporting any missing conduit, sharp edges, missing bushings or drag lines, blocked runs, etc., prior to attempting installation of wire and cable.
3. The Sound, Video & Communication System Contractor shall ensure that the wire and cable is installed in a manner that shall neither cause nor permit damage to the wire and cable throughout the installation process. Damaged wire and cable (including wire and cable spliced in violation of specified requirements) shall be rejected and replaced by this Contractor at no cost to the Owner.
4. All microphone level, line level, video/RF level, Data level, low impedance loudspeaker level, and AC power level wiring shall be restricted to individual and separate conduit systems.
5. All microphone and line level wiring shall be balanced and floating, unless otherwise indicated.
6. Take all necessary precautions to prevent electromagnetic, electrostatic, and radio frequency interference.
7. Care should be taken in wiring and installation to prevent damage to wire or equipment. All wire entering racks or other equipment shall have a service loop of at least four (4) feet unused (slack) length after termination. This service loop shall be neatly bundled and harnessed in place.
8. No splices shall be allowed in microphone, line level, video/RF or data cables unless it is physically impossible to install the wire in one length. Splices must be approved by the Consultant on a case-by-case basis. When approved, the following splicing methods may be used:
 - a. Crimp-type "butt" splice connectors with an appropriately sized shrink tube for each conductor, as well as an overall shrink tube for all audio and intercom cable splices.
 - b. Female BNC "barrel" connectors for video/RF cable. Male BNC connectors shall be provided on cable ends at location of the splice.
 - c. Female 8P8C (commonly known as RJ45) "barrel" connectors for Data cable. Male 8P8C connectors shall be provided on cable ends at the location of the splice.
 - d. Splices in loudspeaker cable are permitted without prior approval by the Consultant. Such splices shall be kept to a minimum.
 - e. Any splices made shall occur only at junction boxes, pull boxes or other permanently accessible locations. Such splices shall be listed on a schedule provided with the as-built documentation.

C. Flexible Cords and Cables:

1. Flexible cords used shall be selected giving consideration to ambient and conductor temperatures, wear-resistance, flexing, and mechanical stress. Vulcanized rubber, butyl rubber, EP, or silicone rubber insulated cables shall be used in preference to PVC insulated types, wherever possible. All flexible cords and cables shall comply with the current edition of the applicable local Electrical Codes and appropriate regulations as identified in "Part 1 - General: Safety and Code Requirements".
2. Flexible cables used as hanging or trailing leads, for power or control circuits, shall comply with the previous clause and shall, if under tension, be fitted with a strain-relief center core that shall be clamped at both ends to relieve the strain on conductors. Trailing leads shall be of a suitable length for the actual application.
3. The segregation of conductors carrying different category circuits shall be as defined in the applicable regulations (local, state and national Electrical Codes and elsewhere herein) and shall be maintained in all flexible cables used. Adequate insulation shall be ensured on all multicore and control circuits.
4. Where the final connection to any equipment is by means of a flexible cable, such flexible cable shall have the same current rating as the rest of the circuit. The current ratings for the ambient temperature shall be as given in the applicable local Electrical Code.

D. Labeling and Marking:

1. All Sound, Video & Communication System wire and cable shall be logically and permanently marked by the Sound, Video & Communication System Contractor. All wire shall be identified at each termination point, and shall be marked to indicate the discrete destination (i.e., a wire shall show the reference number of the jack or connector to which its other end is terminated). All cable markers shall bear the alphanumeric characters of the circuit shown on the approved shop drawings.
2. Wire and cable shall be marked with an approved system of durable identification markers, such as slip-on type PVC or neoprene sleeves, or with directly heat stamped characters. The use of computer-generated labeling systems, such as the Brady DAT-34 or DAT-37, is recommended. Cloth, vinyl or P-Touch tape-type markers are not acceptable.
3. The individual pairs of multipair cable and individual conductors of multiconductor cable shall be readily identified by permanent color coding of the wire insulation. Multipair or multiconductor cable that is identified only by means of the form or order of lay of individual wire is not acceptable.
4. All spare wire shall be marked "spare" at both ends and numbered consecutively. A "spare schedule" shall be provided indicating spare wire and cable numbers, locations and types.

E. Termination:

1. All connections and joints shall be made with rosin-core solder or an approved mechanical connector.
2. All multipin connectors shall have crimp-type gold-plated contacts.
3. All Contactor-terminated data cables & connections must be "certified" using industry-standard testing and verification equipment.
4. Where flexible cable joins fixed wiring the terminations shall be accomplished with either a pair of appropriate mating connectors or a suitable terminal block.
5. All terminations of shielded cables shall consist of a PVC or neoprene heat shrink sleeve covering the shield drain wire and an overall PVC or neoprene heat shrink sleeve covering the point at which the cable jacket and shield end.

- F. Audio Grounding:
1. All shielded cables shall have their shields isolated from both the conduit system and any other shielded cables. Shields shall be continuous from source to input points. Shields shall be connected at input points only, with shields lifted at the source, except as noted below.
 2. Microphone wiring shall have continuous shields from the microphone receptacle to microphone patch jack.
 3. Tie-line patch points shall have continuous shield connection from one patch jack to another with no permanent connection to the audio ground network.
 4. Unbalanced wiring, such as used in certain communication systems, shall have audio shields connected at device inputs and floated at device outputs. Strap shield to "low" side of unbalanced input.
 5. No "doubling up" of ground points on multipin connectors or terminal blocks shall be allowed.
- G. AC Power System:
1. AC power for the Sound, Video & Communication System, provided by the Electrical Contractor, is distributed at 120VAC, 60Hz. Refer to the electrical plan for further information.
- H. Grounding:
1. The Sound, Video & Communication System audio ground network ("audio ground"), including ground source, ground conductors, and ground distribution points is provided by the Electrical Contractor. The isolation and ground continuity of this network, although the responsibility of the Electrical Contractor, shall be confirmed by the Sound, Video & Communication System Contractor prior to installation of equipment. Any ground shorts or faults shall be reported to and corrected by the Electrical Contractor.
 2. The audio ground network shall be isolated from all other electrical grounds except at the source of the ground network, the building safety ground, specified to be of high quality. Therefore, if the connection between the audio ground network and the source of the ground is disconnected, no continuity shall exist between the audio ground and the building electrical ground shall exist.
 3. The Sound, Video & Communication System audio ground network connects all Sound, Video & Communication System equipment positions together by a single, low impedance, ground network. All AC power wall receptacles in Sound, Video & Communication System areas, provided by the Electrical Contractor unless otherwise indicated, will be the isolated ground type, connected only to the associated audio ground spur in that area.
 4. All Sound, Video & Communication System equipment racks containing active electronics shall be connected to the audio ground network, except as otherwise noted in this specification. Caution must be exercised so that these racks are not permanently, or in any way during operation, capable of being accidentally connected to the building safety ground.
 5. All conduits and back boxes containing Sound, Video & Communication System wiring shall be permanently connected to the building electrical safety ground.
 6. Video (RF) and infrared (RF) devices, being unbalanced in nature, shall not be connected to the Sound, Video & Communication System audio ground network.
- I. Electrical Safety:

1. No voltage in excess of 25V rms AC or 24V ripple free DC shall be exposed to touch in normal use or in any equipment by the withdrawal of modules or of any plug or connector or without the removal of suitably indelibly labeled covers.
 2. Unless specifically excepted, all live electrical parts above 50V rms AC or 60V ripple free DC, including terminals, shall remain completely shrouded by insulation or grounded metal when the main access panels are removed. The separate shrouds or covers shall require a tool to remove them to prevent inadvertent contact with live parts.
 3. In addition, where enclosures or items of equipment containing predominantly control, computer, or similar low voltage signals also contain voltages in excess of 50V rms AC or 60V ripple free DC, clear standard warning notices indicating the maximum voltage present shall be provided on all removable access panels. Similar warning notices shall be provided where voltages exceeding 120V are present in any enclosure or item of equipment and such a voltage would not reasonably be expected to be present.
 4. Within enclosures, racks and panels identify with prominent, standard, and indelible signage, which circuit breakers or disconnects are to be switched off in order to isolate the equipment totally. Warning notices shall also be provided on all equipment that contains live terminals after operation of its circuit breaker or disconnect. These terminals must be completely shrouded to prevent inadvertent contact.
 5. All equipment, control stations, equipment racks, enclosures and all metal cases, raceways, and conduit shall be efficiently grounded. Special hand held or portable equipment that is not double insulated shall have duplicated grounding connections. All grounding shall be in accordance with the current edition of the applicable local, state and national Electrical Codes and as identified within this Section and Division 13.
- J. Control System Voltage:
1. Control circuits shall generally be operated at a maximum of 24V AC or DC as appropriate, and in compliance with the provisions described. Hand held control panels shall not contain line (120V) voltage unless approved. Special arrangements to feed movable panels with both line voltage and control voltage must provide suitable mechanical protection and ensure separation of services using the correct category of cable as defined in the codes and regulations identified in "Part 1 - General: Safety and Code Requirements".
- K. Equipment:
1. Operating parts of all equipment shall be suitably machined and finished. Tolerances, fits, finishes, etc., where not specified herein or indicated on the drawings, shall conform to best trade practices and the operational intent of the equipment.
 2. All components shall be of new or recent manufacture, built within two (2) years of the date of installation and never used prior to installation.
 3. All components and items used in Sound, Video & Communication System shall be by a recognized manufacturer specializing in professional Sound and electrical equipment and shall conform to applicable industry and code standards.
The quality of workmanship and materials of all equipment and components requiring custom fabrication shall be comparable to that of professional audio equipment as produced by specialized original equipment manufacturers.
 5. All components used in the equipment installations shall be selected on the basis that each item, or a similarly performing substitute, will be obtainable by the Owner for a period of five (5) years should further spares be required.
 6. All electronic components shall be readily available from at least two recognized manufacturers.
 7. Custom firmware (EPROM, ROM, etc.) shall be supported by readily available spares.

8. All equipment forming part of a given system or installation, and all like components, spares and replacements shall be electrically and mechanically interchangeable.
9. Electrical and electronic components shall be selected for long operating life and reliability. The design of components and assemblies shall ensure that all such components work at a minimum of 25% less than their maximum ratings.
10. All integrated circuits containing program code and all circuits with twenty four or more pins shall be mounted in sockets.
11. All indicators, controls, fuses, relays, contactors, printed circuit cards, and other major components shall each be fitted with a permanent label indicating their type, rating, and duty to expedite any necessary replacement or fault finding. Where applicable, a means of identifying normally open, normally closed, and other contact configurations shall be marked on the component.
12. Annunciators, indicators, and fuses in individual power and electronic systems shall be standardized and approved by the Consultant before design is finalized. Indicating devices shall be of as few different types as possible and wherever practicable shall have a minimum life of 10,000 hours.
13. All contactors and relays (although not necessarily special approved types such as reed relays) shall be of the snap-track type developed for mounting inside equipment rack. Generally the contact rating shall be twice the expected maximum operating or inrush current whichever is the greater.
14. Fuses and circuit breakers shall be panel mounted. Fuses shall be mounted in indicating fuse holders, illuminated when the fuse has failed. Where fuses must be concealed they shall be easily accessible. All panels with concealed fuses shall be marked accordingly on the outside and shall have panel mounted indicator lights. Spare fuses shall be provided in holders mounted within the panel.
15. All internal switches shall be clearly and permanently labeled.
16. All connectors external to the equipment shall be rugged metal construction with self-contained locking devices. Non-metallic external connector shells are unacceptable.
17. All keyswitches and keylocks for similar components shall use the same key. Unless otherwise specified, keys shall be removable in all positions. Supply four (4) key copies for each keyswitch/keylock.
18. All edge connectors, ribbon cable connectors and headers shall have gold-plated contacts. All IC sockets shall be of a face wipe, gas-tight design.

L. Assemblies:

1. Manufacturing, assembly, and wiring work shall be carried out by trained and experienced technicians.
2. Ensure that all parts and components of electrical, electronic, or computer installations are readily accessible for inspection, service, and maintenance. All components shall be replaceable without removal of operational components other than those mounted on or carrying the faulty component. All parts shall be replaceable without strain or damage to other parts.
3. Electrical and electronic systems shall be constructed as separately removable modules. Where a system comprises a large number of similar modules, these modules shall be designed so as to be easily interchangeable. Where such equipment is of a plug-in type, withdrawing or replacing the modules with the power "on" shall not cause damage to the units or to other equipment.
4. Electrically dissimilar modules or connectors shall not be able to be wrongly connected. Operating surfaces of control panels/conssoles shall be of steel, aluminum, or other rigid material, reinforced where necessary to prevent noticeable panel deflection. Generally, all sides of a control panel shall be fully supported.

5. Where possible all control and connection panels shall have hinging or drawer access to electronics for installation and maintenance. Panels shall be held closed by captive quick locking hardware. Provide terminal strips, and neatly bundled wiring to facilitate access. Captive fasteners shall be provided for all removable panels or parts. Any inaccessible nuts shall be fixed. Countersunk or instrument head screws shall be used on external surfaces.
- M. Custom Fabrication:
1. Particular attention shall be paid to the selection of operational components used on custom pendants and control panels. All such components shall be selected for long life under arduous conditions, including rough use in a dusty and dirty environment.
 2. Pushbuttons, selector switches, key switches, operating knobs, handles, and similar shall all be rugged industrial-type components, firmly mounted and capable of giving long trouble-free service. Commercial-grade units will not be accepted.
- N. Finishes:
1. Unless otherwise indicated, all steel equipment cabinets and panels shall be finished with one coat of primer and two coats of semi-gloss baked enamel after full degreasing and rust preventing processes. Colors shall be as selected by the Consultant or as specified herein.
 2. Aluminum panel surfaces shall be anodized black or other color as indicated herein or on the drawings.
 3. Finishes subjected to high temperatures shall be of heat-resistant epoxy or other durable high-temperature baked-on enamel finish.
 4. Finishes shall be durable and capable of withstanding normal usage in the areas in which they are installed.
- O. Equipment Racks:
1. All internal wiring of electrical, electronic or computer equipment shall be in accordance with the current editions of the applicable Electrical Code and governing regulations as identified in "Part 1 - General: Safety and Code Requirements".
 2. All internal wiring shall be of adequate mechanical strength as well as electrical current rating. Multistrand cables shall be used for low current wiring in preference to solid conductors. The current carrying capacity of all cables within equipment enclosures shall take account of derating factors and ambient temperatures in accordance with applicable local, state and national Electrical Code regulations.
 3. All terminal strips shall be logically positioned and indelibly marked in accordance with the circuit drawings. Generous space shall be left for installation of the external cables.
 4. All terminals, to which connections are to be made by Division 16, shall have clear markings that are unique for each terminal and are as identified on the shop drawings.
 5. All internal wiring shall be color coded and contained within raceways. At least 40% space shall be available as initial spare capacity. All the conductors of a given power circuit shall be contained within the same conduit or raceway. All internal wiring shall be protected from mechanical damage.
- P. Labeling:
1. All wall receptacle plates shall be engraved and filled to indicate the reference number of the circuit to which each is attached. Such numbers will, when applicable, be referenced to the patch panel jack to which the circuit connects. Refer to the contract drawings for reference numbers and designations.

2. Panels and receptacles must be readable in dim lighting. Quality of engraving and filling, letter sizes, etc. shall comply with "Part 2 – Products: Receptacle Plates" of this specification and as approved by the Consultant through shop drawing and sample submittal.
3. All legends shall be engraved and filled in a color as indicated on the drawings, unless otherwise noted below.
4. Where required, engraved, adhesive-backed lamacoid labels shall also be mechanically fixed in place only in those cases where there is no risk of damage to a device's internal components or wiring.

Q. Noise from Equipment

1. The residual noise and hum output of the systems shall be such that PNC-15 or below can be measured at the center of main floor, and the character of the remaining noise must be random, with no audible discrete frequency components.
2. Where a control panel or rack is to be used or located in an operational area, such as on stage, a gallery, or control room, there shall be no acoustic noise associated with the panel. No internal cooling fans or similar moving or magnetic equipment shall be permitted unless approved by the Consultant in writing.
3. Operation of switches, pushbuttons, relays, solenoids, and sirens shall not be audible to members of the audience (even in the control rooms with the window open).

R. Spare Parts

1. Supply spare parts to be stored on-site for all user serviceable equipment and systems. A sufficient quantity of bulbs, fuses, knobs, switches, and other miscellaneous parts shall be supplied. Refer to "Part 2 - Products" for specifics of electronic and transducer parts to be supplied.
2. Label all spare parts with manufacturer's part number, designation, description, and location(s) where part is used. Provide neatly labeled storage containers for all spare parts, including special static free wrapping for electronically sensitive parts.
3. The spare parts shall be released to the Owner after completion of the commissioning procedure.

S. Site Work

1. The Sound, Video & Communication System Contractor shall be responsible for delivery, storage, and handling of equipment and tools during the period of the installation.

T. Painting

1. Except for special requirements as approved by the Consultant, each painting system shall use paint products of one manufacturer to ensure compatibility of primer and undercoat with top coats.
2. All paint products shall be factory prepared of the best grade and quality (front line) produced by the manufacturers, subject to approval by the Consultant.
3. Finish coats on components exposed to view at all locations shall be two (2) coats of approved finish.
4. The Sound, Video & Communication System Contractor shall be held wholly responsible for the finished appearance of the painting work. Painting will be in accordance with the highest standards of the trade.
5. All components exposed to view shall be shop painted to match approved samples.

6. Re-touch all shop painted or finished work wherever necessary or as directed, including unpainted screws and other fasteners. Prime paint all patched portions in addition to all other specified coats.

U. Protection Of Work

1. Shipping and Storage

- a. The Sound, Video & Communication System Contractor shall be responsible for the satisfactory packing and protection of all components and materials for shipment from the factory to the site. Any items suffering damage during transit due to unsatisfactory packing shall be replaced without charge to the Owner.
- b. All equipment shall be packed to withstand the intended method of transport and environmental conditions expected. This Contractor shall take full account of the effects of rough handling, temperature extremes, dust, heavy rain, direct sunlight, and high relative humidity (up to 99%) during transit and installation. The packing shall, where necessary, reduce the effects of condensation.
- c. All equipment shall be packed in sturdy containers to provide mechanical protection during shipping and storage. Provide padding, etc. as necessary to protect the equipment from vibration and shock.
- d. Inner plastic sheeting shall be provided to protect the equipment from moisture and dust. Such covers shall be kept on equipment until environmental conditions have stabilized and the installation areas have been completed.
- e. No equipment shall be shipped to the job site by this Contractor until notification by the Contractor that storage facilities are available to protect the equipment prior to installation.
- f. The Sound, Video & Communication System Contractor shall be responsible for storage and protection of portable equipment and components until turning these items over to the Owner during commissioning. Instruct the Owner as to the proper method of storage and protection of the equipment during installation.
- g. Refer also to the General Conditions, as amended by the Supplementary Conditions.

2. Installation

- a. Installation shall be authorized only when site conditions provide mechanical, electrical, and environmental protection suitable for the electronic equipment.

3. Special Protection of Electronic Equipment and Cable

- a. This Contractor shall conform with the following minimum standards and procedures for the storage and protection of the equipment during installation:
- b. Class 1 - Cable and distribution apparatus, back boxes, face plates, terminal boxes, and rack frames may be stored and installed in weather-protected spaces under "normal" construction site conditions provided that no electronic components are contained within devices and provided that storage boxes are sturdy, well sealed, and devices are protected with imperforate inner plastic sheeting. When installed, devices must be protected from dirt, dust and moisture by sturdy impermeable plastic sheeting, and completely covered with heavy corrugated cardboard, held in place securely by duct tape. Covers shall not be removed until the area is broom cleaned. Care shall be taken to prevent damage and prolonged exposure to improper site conditions during installation. In no case shall devices remain uncovered overnight during installation or while work is taking place causing high dirt dust or moisture levels in the area of placement.
- c. Class 2 - Control panels, spare parts, and test equipment (except as listed under Class 3) shall be protected and treated as per the Class 1 devices with the following additional provisions: Equipment shall be stored in an air-conditioned secure

space. Equipment shall not be shipped until such space exists on site and is approved by the Consultant and Contractor. Control panels with electronic components may be installed providing they are protected as described under Class 1 description above, but electronic components must be removed and shall not be installed until the area of installation is broom cleaned and all dirt, dust and moisture producing work is completed in the area. All other equipment in this class shall not be installed until the area of installation is broom cleaned, "blown" clean with pressurized air, mopped, secure, and air conditioned.

- d. Class 3 - Mixing consoles, filled equipment racks, and other electronic equipment shall not be shipped to site until the control rooms are finished, air conditioned, dust free, broom and mop cleaned, secure, and in all respects complete and ready for occupation. This class of equipment shall not be unpacked until the system is complete in all other respects. Under no circumstances may any equipment in this class be removed from the control rooms into or through spaces that are not cleaned, air conditioned, and complete.

3.4 TESTING AND ADJUSTMENT

A. General

1. Perform tests and adjustments to the Sound, Video & Communication System as outlined in this specification. These tests and adjustments shall be completed at the time(s) specifically indicated in "Part 1 - General: Commissioning."
2. Provide a minimum of two qualified technicians to assist in tests, adjustments, and final modifications during the testing and adjustment period.

B. Preparation

1. Ensure that all equipment racks, panels, and rack boxes have been adequately cleaned of dirt, dust, and debris. Reassemble all equipment and replace all panels and covers with the necessary screws and/or other appropriate hardware prior to the final site inspection.
2. Before applying AC power to Sound, Video & Communication System equipment, perform a complete system inspection on the site to verify that all items are correctly installed and will operate safely as specified in the Contract Documents.
3. Verify also that each individual section of the Sound, Video & Communication System has been correctly installed and is fully operational.

C. Conditions

1. Do not use any major control equipment intended for installation in the Sound, Video & Communication System for the purpose of checking or testing wiring or circuitry until such time as requirements for "Class 3" equipment meet the environmental conditions described in "Special Protection of Electronic Equipment and Cable" above. Provide testing apparatus, substitute control equipment, or other devices for testing wiring and circuitry prior to the existence of these conditions at all locations of Sound, Video & Communication System equipment.
2. Electroacoustic measurements shall only be made once all interior room finishes are completed and all performance equipment is in place and operational. Such equipment includes, but is not necessarily limited to, audience chamber seating, acoustic isolation doors, acoustic canopies, and acoustic control curtains and banners.

D. Test Equipment

1. The following test equipment, provided at the expense of the Sound, Video & Communication System Contractor, shall be available on site during all testing and adjustment sessions, initial and final site inspections, and demonstration and instruction sessions. Provide all appropriate monitors, adapters, cables, and connectors necessary to interconnect the test equipment devices to each other and to the Sound, Video & Communication System equipment.
 - a. Multi-Function Audio Signal Generator/Analyzer
 - 1) Neutrik Minirator MR2 / Minilyzer ML1, or approved equal
 - b. Digital Multimeter
 - 1) Fluke 77 IV Series, or approved equal.
 - c. Polarity Testing System
 - 1) LA Audio PC90 or approved equal
 - d. Impedance Meter
 - 1) Goldline ZM-1, or approved equal.
 - e. Sound Level Meter
 - 1) MiniAnylyzer, approved equal
 - f. Two-channel FFT-Based Electroacoustic Analysis System
 - 1) SIA SMAART
 - 2) General: Computer-based electroacoustic measurement system requiring proprietary equipment and a certified operator. Provide dual-channel FFT transfer-function measurements, phase response delay locator and real-time analysis and ability to perform these measurements with test signals and with program (music) occurring during performance.
 - g. Two-Way Radios
 - 1) Motorola UHF, or approved equal.
 - 2) Quantity: Six (6) , with spare battery & charger.
 2. Requests for alternate test equipment shall be submitted to the Consultant for approval shall meet or exceed the manufacturers' published specifications for the above components. No exceptions. Non-professional test equipment, including "custom-built" components, shall not be acceptable.
- E. Procedure:
1. Perform the following tests and adjustments to the Sound, Video & Communication System. All test results and system adjustments shall be fully documented for inclusion in the Initial and Final Test Reports. Refer to "Part 1 - General: Commissioning".
 2. Continuity
 - a. All permanent Sound, Video & Communication System wire and cable shall be tested for continuity after installation in conduit and before termination in panels or racks. Also test for shorting contact between any and all conductors in a multipair or multiconductor cable and between each conductor and the conduit (building safety ground). Use a continuity meter for all tests.
 - b. All Sound, Video & Communication System wirepaths shall be tested to ensure that device inputs and outputs, assigned to particular circuits or channels, terminate to the correct location, and that all corresponding labeling is accurate.
 - c. Measure and verify electrical and electroacoustic polarity of all Sound, Video & Communication System components to ensure that the entire system is properly connected (i.e., the system shall be "in phase"). Ensure that absolute polarity is maintained throughout all signal paths, regardless of patching or other routing changes.
 - d. Document all wiring or termination changes made in order to maintain system polarity.

3. Impedance
 - a. Measure and document the impedance of each microphone and line level line terminated with a 600-ohm 1% precision resistor, at 250Hz, 1kHz, and 4kHz, while disconnected from any device input. The load impedance value shall be greater than the resistive load.
 - b. Measure and document the impedance of each low-impedance loudspeaker line to an unconnected receptacle, at the patch panel, terminated at the opposite end with an 8-ohm 1% precision resistor, at 250Hz, 1kHz, and 4kHz, while disconnected from any device input. The load impedance value shall be greater than the resistive load.
 - c. Measure and document the impedance of each low-impedance (nominal 2 to 8-ohm) loudspeaker line while disconnected from the power amplifier. The load impedance value shall be greater than the total rated impedance of all connected loudspeaker drivers.
 - d. Test each full-range loudspeaker line at 63Hz, 250Hz, 1kHz, 4kHz, 8kHz, and 16kHz.
 - e. Test each band-limited loudspeaker line (i.e., bi-, tri-, or quad amp systems) at the maximum number of test frequencies that fall within the frequency range of the driver under test.
 - f. Measure and document the impedance of each 70.7V loudspeaker line at 250Hz, 1kHz, 4kHz, and 8kHz, while disconnected from the power amplifier. The load impedance value shall be greater than the total rated impedance of all connected voice-coil transformers.
4. Radio Frequency Interference
 - a. Use a minimum 60 MHz bandwidth analyzer in conjunction with loudspeaker or infrared receiver/headset monitoring to ensure that the Sound, Video & Communication System under test is free of spurious oscillation and radio frequency interference (RFI). Measure and document all results.
5. Gain Structure
 - a. Set and document input and output gain controls on all Sound, Video & Communication System components to provide appropriate signal balance (i.e. unity gain) and optimum signal-to-noise ratio for each signal path. Unity gain shall be set by adjusting the gain of each active device (excluding power amplifiers and mixer/amplifiers) for input level equals output level by using a reference signal of 0dBV pink noise at the mixing console output.
 - b. Ensure that a minimum of 18dB of headroom exists for each gain stage. The overall system gain (excluding mixer/preamplifiers, mixer/amplifiers, and power amplifiers) through any signal path from any input to any output shall be unity + 1.5dBV.
 - c. Conduct listening tests from center of coverage of each high-frequency horn device to determine that there is no audible hiss or distortion.
6. Electronic Signal Path
 - a. Measure and document frequency response, signal to noise ratio (S/N), maximum output before clipping, total harmonic distortion (THD), and any spurious noise and/or hum signals of all electronic components in the Sound, Video & Communication System. Measured values must be as published by the manufacturer, or better.
 - b. With unity gain levels set, measure and document electrical frequency response for all discrete signal paths from the mixer through each active device, including mixer/amplifier outputs with the loudspeaker lines disconnected. Also test typical signal paths through each combination of mixer input to output. Use a -60dBV

- (0.8mV RMS) sine wave signal at microphone inputs from 20Hz to 20kHz and a 0dBv (0.775 VRMS) sine wave signal from 20Hz to 20kHz at line level inputs. Deviation shall be within +/-1.0dBv from the range of 30Hz to 20kHz, or the specified bandpass for a particular circuit. (Refer to manufacturers' published data).
- c. With unity gain levels set, measure and document signal to noise ratio for all discrete signal paths from the mixer through each active device with mixer input shorted.
 - d. Measure and document maximum output before clipping (headroom) and total harmonic distortion of each active device with methods recommended by the equipment manufacturer.
 - e. With unity gain levels set, measure and document any spurious noise and hum signals such as 60Hz, 120Hz with harmonics, high frequency oscillation, clicks, pops, or noise spikes for all discrete signal paths from the mixer through each active device, including the mixer/amplifier outputs with loudspeaker lines disconnected. If any unwanted signals are detected, troubleshoot and correct or modify as necessary.
7. Power Output
- a. Measure and document the output power of each power amplifier and mixer/amplifier, using a sine wave oscillator with less than 0.5% THD as an input source. Terminate each power amplifier channel output with a load resistor to match the nominal loudspeaker impedance. Apply a 1kHz signal at a level to achieve 10 dB below full rated power output of the mixer/amplifier. Observe the sine wave with an oscilloscope to insure that full voltage for rated power can be reached without noticeable deformation of the waveform.
8. Buzzes, Rattles, Distortion
- a. Apply a sine wave sweep at a slow rate from 30Hz to 10kHz at 6dB below full rated power output of each amplifier in the Sound, Video & Communication System with output connections made to all loudspeaker drivers or voice-coil transformers. Adjust test frequency range to compensate for band-limited low-voltage loudspeaker lines (i.e., bi-, tri-, or quad-amp circuits) or 70.7 volt loudspeaker lines. Listen carefully to each loudspeaker for electromechanical buzzes, rattles, distortion, or other objectionable noises and correct all causes of such defects. If cause is outside Sound, Video & Communication System equipment and/or the scope of this section of the contract, promptly notify the Owner and Consultant of the cause and suggested corrective procedure.
- F. Sound, Video & Communication System Testing
1. The following Sound, Video & Communication System Tests shall be conducted as part of the SMAART measurement and optimization process. Sound, Video & Communication System Testing will require two 8-hour sessions scheduled to ensure quiet ambient noise levels in the test area. The Sound, Video & Communication System Contractor shall provide a certified SMAART technician to operate the SMAART System.
 - a. Sound Pressure Level: Measure and document sound pressure level of loudspeaker arrays throughout the seating areas and adjust suspended loudspeaker aiming, as necessary, to achieve a coverage of +/- 3dB, or better, with a peak continuous level of 105dB SPL. Take all readings at seated ear level height.
 - b. Loudspeaker Array Driver Alignment: Measure and document the loudspeaker driver alignment of the components of each loudspeaker array. Adjust precision

signal delay units as necessary to achieve the best average signal alignment between adjacent components.

- c. Frequency Response: Measure and document the frequency response of each loudspeaker array, as measured in both the reverberant field and near field (with windowed FFT methods), to ensure that the frequency response is within +/-3dB from 100Hz to 3kHz, and rolls off at a rate of 3dB/octave +/-3dB from 3kHz to 12kHz (and beyond, if possible). Apply the pink noise source at a line input of the mixing console. Adjust fixed Sound, Video & Communication System equalization as necessary. If discrepancies arise, the final curve shall be based on the average of the values measured. Hard copy documentation shall be recorded for both time-energy-frequency analysis and ISO one- third octave band frequency response measurement.
- d. Speech Intelligibility: Perform subjective and/or objective speech intelligibility measurements or surveys throughout the facility and make adjustments as necessary to the Sound, Video & Communication System for maximum speech intelligibility. Submit proposed methods of testing to the Consultant for approval.

3.5 PROGRAMMING

- A. At the completion of the Testing process, and in conjunction with the Consultant, Project Architect and Design Team, and other trades, the Sound, Video & Communication System Contractor shall provide full time technical support for ten (10) 12-hour days of Ride Programming. Two (2) technicians shall be provided for the entire duration of the Programming period.
- B. Technical personnel should be prepared to adjust loudspeaker positions, facilitate required changes to Sound, Video & Communication System equipment programming, and troubleshoot any technical problems that may arise during Ride Programming Sessions.

END OF SECTION

SECTION 27 50 00 - INTERCOM AND CLOCKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. This section and associated drawings define a communications system for an intercom, public address and master clock system. The contractor shall provide all infrastructure, cable, hardware and equipment as defined to provide complete and operational systems.

1.2 SYSTEM DESCRIPTION

A. Design Requirements

1. Intercom/PA/Master Clock System

- a. The facility intercommunication system shall be a low voltage system that utilizes a fiber and copper cable infrastructure to distribute a user-defined input in a single and bi-directional manner. The system shall be capable of multiple simultaneous conversations on separate channels throughout the facility through VoIP telephones and loudspeaker assemblies.
- b. A programmable master for tone distribution schedule shall also be included as part of the overall system.
- c. The system shall be microprocessor based and have interconnection with the telephone system installed within the facility. In addition, the system must be expandable to meet the user's future expansion needs and be programmable from a computer terminal located at the facility.
- d. The clock system shall consist of a master unit and slave clocks. The system shall be wirelessly corrected and have electrically powered clocks. All clocks shall be corrected wirelessly to the master clock system.

B. Performance Requirements

1. Rack/Cabinet mountable headend equipment.
2. Announcement distribution from a central location to zones, individual classrooms, groups or all facility speakers.
3. Broadcast of user defined input (radio signal, compact disc, aux input, etc.) to zones, individual rooms, group or all facility loudspeakers.
4. Emergency call to all speakers in an emergency situation from a central location.
5. Two-way intercommunication between the central rack, any call-in location or any selected two-way speaker location.
6. Hands free communications by means of a loudspeaker or speakerphone used as a transducer or speaker/microphone combination.
7. Remote audio monitoring of all intercommunication system activity.
8. Volume and level controls for all centrally located intercommunication system equipment.
9. Tone distribution based off the master clock that can be partitioned into zones.
10. Capability to tie into any auxiliary sound system throughout the facility.
11. High priority call-in from any telephone/call switch in an emergency situation.

C. Regulatory requirements

1. All work will conform to the National Electric Code and applicable local ordinances.

1.3 SUBMITTALS

- A. Comply with requirements of Division 0 and Division 1 - Submittals and as modified below.
- B. Product Data: Submit manufacturer's product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.
 1. Submit the shop drawings, product data and quality control submittals specified below at the same time as the package
 2. Shop Drawings shall include the following items but are not limited to:
 - a. Equipment and device quantities and types
 - b. Wire types
 - c. System wiring diagrams showing all connections
 - d. Drawings including all equipment locations
 - e. Associated equipment specifications and cut sheets
 - f. Product data including catalog cut sheets, manufacturer's default specifications, user operation guides and a bill of materials
- C. Quality Control Submittal
 1. Submit the name, address and telephone number of the nearest full service service organization.
 2. Submit a certificate of completion of installation and service training from the system manufacturer.
 3. Certificates
 - a. Manufacturer Certification: Submit certificate from manufacturer of products to be installed under this contract certifying that Installer is authorized by manufacturer to install specified products.
 - b. Installer Experience Listing: Submit list of at least 5 completed projects as specified below in "Quality Assurance – Qualification – Installer."
- D. Contract Closeout Submittal: Comply with requirements of Division 0, including submission of operating and maintenance instructions as item in "Operation and Maintenance Data" manual described in that Section

1.4 AS-BUILTS

- A. All systems must have as-built drawings provided in electronic CAD and hardcopy format that clearly show all system components, wiring schemes and system interconnections.

1.5 QUALITY ASSURANCE

- A. All Work shall be installed in a first class, neat and workmanlike manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized school personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of the school systems is obtained.
- B. Qualifications
 1. Installer

- a. Must be qualified to cable, terminate, install and program the equipment specified in this Section, certified by manufacturer of products to be installed, and completed at least 5 installations of similar size, nature and complexity as specified for this project.

1.6 WARRANTY

- A. Special Warranty: Provide manufacturer's system warranty against electrical or mechanical defects for 1 year from date of final acceptance.
 1. System Assurance: The System Assurance shall cover the failure of the wiring system to support the application which it was designed to support as well as additional application(s) introduced in the future by recognized standards or user forums
 2. System Certification: Upon successful completion of the installation and subsequent inspection, the Authority shall be provided with a numbered certificate, from the manufacturing company, registering the installation.

1.7 TRAINING

- A. Installing contractor shall provide a minimum of 8 hours of training on system operation and managements as part of their scope of work.
 1. Additional hours shall be provided on a time and materials basis at the request of the owner.
- B. Installing contractor shall provide a video recording on a standard format DVD to the owner which includes training sessions.

1.8 OPERATION AND MAINTENANCE MANUALS

- A. Installing contractor shall provide a minimum of two hard copy and one electronic copy of all operation and maintenance manuals to the owner at project completion.
- B. All passwords and software must be included for the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable manufacturers:
 1. The intercom and clock systems shall be manufactured by a reputable manufacturer with a proper support and maintenance operation in place.
 - a. Intercom - Rauland
 - b. Clock - Rauland
 2. Substitutes
 - a. Telecor
 - b. Bogen
 - c. Valcom
 - d. Any proposed substitute must have identical system architecture and function in an identical manner to the designed solution.
 - e. Burden of proof rests on the submitting contractor to provide information that the proposed substitute meets the design criteria.

2.2 MATERIALS

A. PRODUCT OVERVIEW.

1. Intercom/PA Master Clock System and Equipment

B. J-Hooks

1. Cooper B-Line BCM-21, 23 or 64.
 - a. Provide in sufficient quantity for 15% future expansion.
 - b. Installed no more than 6' apart.
 - c. Install in any areas without cable tray above false ceilings.

C. Headend

1. Equipment Cabinet
 - a. 19" Equipment Cabinet with fan kit

D. Patch Panels

1. See Section 271000.
2. Product shall match.

E. Patch Cords

1. See Section 271000
2. Product shall match.

F. Network Switches

1. Provided by owner
2. Installed by this contractor

G. Server

1. Full TCU District Server (Add alternate)
2. Lite TCU Server (Base-bid)

H. Controller

1. Telecenter TC2000 Controller

I. Classroom Module

1. Telecenter TCC2011A IP Module

J. Zone Page Module

1. Telecenter TCC2022 Zone Page Module

K. Analog Gateway

1. Telecenter 2024 24 Port Gateway

L. Aux I/O

1. Telecenter TCC2033 Aux I/O Module
- M. IP Admin Handset
 1. Telecenter TCC2045 Administrative Console
- N. Line Input
 1. Telecenter TCC2055 Program Line Input Module
- O. Mic Input
 1. Telecenter TCC2077 Mic Input Module
- P. Multi-Port FXS-FXO Gateway Router
 1. Patton Smart Node 4520
- Q. Breakout Module
 1. Telecenter TCC603101 Breakout Adaptor
- R. Drop-in Speaker
 1. Rauland BAFKIT2X2LRJ
- S. Cut-in Speaker
 1. Rauland ACC1000 with ACC1101.
- T. Surface Mount Speaker
 1. Rauland ACCWB8RJ
- U. Pendant Speaker:
 1. Valcom V-1015
 2. Color selection and wire color selection shall be by architect
- V. Volume Controller
 1. Rauland ACC300
- W. Call Switch with Integrated Speaker
 1. Telecenter TCSPBR with TCDPB2
- X. Paging Horn
 1. Rauland TF-157UCS
- Y. Amplifier
 1. 25v
 2. 70v
 3. 100v
 4. 60 Watt
 5. 100 Watt

6. 250 Watt

Z. UPS

1. 3000 VAC Smart UPS
2. L5-30p

AA. Desk Mic

1. Tascam TM-95GN

BB. Program Sources

1. 5-Disc CD Player
2. AM/FM Tuner

CC. Cable and Jacks

1. 50 Micron OM4 Fiber
2. Cat 6 UTP
3. West Penn 25359B Plenum Rated Wire.
4. PA Cable shall be plenum rated.
5. PA Cable shall be yellow or approved equal.
6. PA Cable must be presented to the school district for approval prior to installation.

DD. Wireless Master Clock System

1. Rauland WCXATRAN
2. Rauland WCXRNRNTP
3. Rauland WCTRWS
4. Rauland WCLFCCNP10

EE. Clocks

1. Rauland WCANA16WG
2. Rauland WCA1312B
3. Rauland WCA1612F
4. Rauland 2415 Power Transformer
5. 3 conductor 14 AWG for Digital clocks.

FF. Spare Capacity / System Expansion

1. The contractor shall include extra circuits for staff telephones and loudspeakers built into the system for future expansion. Contractor shall provide and install fifteen percent (25%) extra capacity (line cards, expanders, etc.) for these devices. The Owner shall add only field instruments (telephones and loudspeakers), cabling, and programming to make these spare capacity circuits fully operational.

GG. Cable and Jacks

1. Singlemode Fiber
2. Cat 6 UTP
3. West Penn 25359B Plenum Rated Wire.
4. PA Cable shall be plenum rated.
5. PA Cable shall be yellow or approved equal.

6. Hallway and exterior speaker runs shall utilize West Penn 25292B Plenum rated cable with no more than 10A per circuit.
7. PA Cable must be presented to the school district for approval prior to installation.

HH. UPS Equipment

1. All system shall be powered via 3000 VAC UPSs and emergency circuits

II. SPARE CAPACITY/SYSTEM EXPANSION

1. The contractor shall include extra circuits for staff telephones and loudspeakers built into the system for future expansion. Contractor shall provide and install fifteen percent (15%) extra circuitry (line cards, expanders, etc.) for these devices. The Owner shall add only field instruments (telephones and loudspeakers), cabling, and programming to make these extra capacity circuits fully operational.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine conditions under which telecommunications cabling and equipment and related components are to be installed in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Design consultant in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected to ensure a safe and timely installation.
 1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Design consultant written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.
 2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.
 3. Verify all dimensions in field and confirm condition of existing hardware to be utilized.
 4. Confirm space requirements and physical confines of all work areas to ensure that all materials can be installed in indicated spaces.
 5. Confirm all device locations and cable pathways and advise Design consultant in writing of any discrepancies or issues in Design described in Contract Documents.

3.2 PREPARATION

- A. Protection: Provide adequate protection of equipment and hardware before and after installation.
- B. Existing Communications Services: Ensure all telecommunications systems (voice, video and data) remain operational throughout the project.
 1. Identify any additional intercom equipment, devices, and wiring at the site not shown on T-Drawings and interfering with installation of specified equipment.
 2. Remove all accessible portions of abandoned communications cabling per NEC 800.52. Tag all communications cabling not terminated at both ends but retained for future use.

3.3 INSTALLATION

- A. Provide and install all components necessary to install complete intercom/PA/master clock system, including (but is not limited to) cable, connectors, patch panels, call switches, speakers, etc...
- B. Secure all horizontal cables within ceiling cavities to building structure.
 1. Loosely bundle all cables and support from structure at unequal intervals from 5 to 6 feet with spring steel fasteners and cable clip rated for use with high performance cables (similar to Caddy Series "CableCat" or approved alternate mounting methods) including placement in cable tray as indicated on Drawings. All mounting clips shall be seismic type as per BOCA.
 2. Do not violate manufacturer's recommended loadings. Leave 30% capacity for future use of pathway.
 3. Verify all horizontal cable run lengths prior to installation. Re-distribute horizontal cabling to maintain distance requirements and maintain pathway route accessibility.
 4. Do not support cables from ceiling grid T-Bars, grid wire supports or bridging rings.
 5. Do not allow cables to touch ceiling grid.
 6. Install cables in EMT conduit in all unfinished, exposed areas as shown in Design consultant roof plans and/or T-Drawings, unless alternate pathways are noted.
 7. Do not secure cables with permanent cable ties. Do not tighten cable bundles in such a way as to cause jacket deformation or damage.
 8. Place cables in compliance with ANSI/TIA-568 standards and BICSI recommended methods.
 9. Re-terminate and re-test any cables or pairs of cables failing end-to-end testing requirements. Replace any faulty cables/pairs or termination devices. Remove all defective cables completely from pathways.
- C. Install all exposed cabling in surface raceway by name brand Hubbell or Panduit where in-wall conduit has not been provided. Follow all manufacturers' guidelines requirements regarding bending radius and slack. All bends, offsets and fittings shall be appropriately sized to provide 30% capacity after installation.
- D. Install all cable in accordance with National, state and local codes and TIA/EIA Standards, and BICSI methods.
 1. Follow manufacturer's guidelines and requirements for all cable termination.
 2. Follow detail drawings to locate equipment racks and cabinets. Where it is necessary to deviate, to obtain 30-inch clearance between equipment, obtain Design consultant's written approval before mounting cabinet/rack.
 3. Ladder-type cable tray shall be affixed 6 inches above all data racks and equipment cabinets, and routed to all points of entry into each telecommunications room.
 - a. Include transition to proper height for penetration into hallway or other wall penetration as indicated on Drawings.
 - b. Install sufficient 4-inch conduits from telecom rooms into hallway (minimum of 2) with protective insulating bushings, cable spillway or specially designed cable tray sections, with appropriate firestop materials.
- E. Properly terminate all cables at speakers, call switches, administrative consoles and distribution racks. Permanently identify all cables in pullboxes, transition points, and termination points by affixing pre-marked self-adhesive wraps similar to Brady "B-500+ Plastic Cloth Markers."

- F. Permanently identify all system components following TIA/EIA-606A “Administration Standard for Commercial Telecommunications Infrastructure” with identification format:
1. Identification: Provide permanent identification labels for end devices and associated cabling at each end.

3.4 TESTING

A. Intercom and Clock

1. Upon completion of work, all parts of the system installation shall be tested by the Contractor and demonstrated free of any defects. Preliminary testing will be permitted but shall not be accepted in lieu of obtaining final test results. Final test results shall be accomplished by the use of proper test equipment for the system being tested.
2. Re-terminate and re-test any cables or pairs of cables failing end-to-end testing requirements. Replace any faulty cables/pairs or termination devices. Remove all defective cables completely from pathways.

B. As-Builts

1. Accurate as-built drawings shall be provided in electronic and hard copy format.
 - a. Drawings shall accurately show and describe all cable routes and equipment location in redline format.
 - b. 3 copies of electronic (CAD) drawings shall be distributed on appropriate media: 1 to construction management, 1 to designers and 1 to the school district.
 - c. 3 hard copies of CAD drawings shall be plotted on full size sheets and test results of every installed cable have been given to the construction management for appropriate distribution.

3.5 ACCEPTANCE

A. Contractors work shall be considered complete after the following conditions have been met:

1. Cable installation is complete and all cable runs have been tested and documented to be installed according to specifications and drawings.
2. A school district Technology representative has successfully tested the “LIVE” system.
3. All punch list items have been reconciled.
4. All disturbed ceiling panels, firestopping materials, covers, etc. have been properly reinstalled.
5. All materials and trash have been removed from the site.
6. A 1-year installers warranty has been given to a school district Technology representative.
7. Submit Manufacturers Extended Warranty Application.

END OF SECTION

SECTION 31 10 00 - SITE CLEARING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Site Clearing shall consist of clearing of the site within the limits of construction to include the following:
1. Removal and disposal of trees and brush, weeds, roots, and similar materials.
 2. Removal and disposal of civil structures, paving, base course, utilities, concrete sidewalks and aprons, and all other obstructions which are designated on the Plans for removal during construction.
 3. Removal and disposal of utilities in coordination with utility companies.
 4. Protection of existing utilities to remain and protection of adjacent property, structures, benchmarks, and monuments.

1.2 STANDARDS

- A. The quality and performance of work specified in this section shall be in accordance with the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction, dated June 2021, latest revision (hereinafter referred to as the "Standard Specifications").
1. Section 201: Clearing and Grubbing
 2. Section 211: Removal of Structures and Obstructions
 3. Section 1047: Flowable Fill

1.3 PHASING

- A. Clearing, grubbing, and removal shall be performed prior to the grading and stripping operations, within the limits of grading, as indicated on the drawings and as specified herein. Following clearing, topsoil shall be stripped and stored for later use on the site or disposition as directed by the Owner.

1.4 PROTECTION

- A. The Contractor shall protect all trees, shrubs, ground plants, roads, walks, pavements, structures, civil improvements, and appurtenances not indicated to be cleared from the site. Methods of protection shall be by use of substantial wood or chain link fences, barriers, or other methods, as approved by the Engineer. Any trees, shrubs, ground plants, roads, walks, pavements, structures, or appurtenances indicated to remain that become damaged during construction of the project shall be repaired or replaced by the Contractor, as directed by the Engineer, at no additional cost to the Owner.
- B. The Contractor shall contact all utility companies to mark the location of their facilities. The contractor shall remove utilities only in coordination with the utility companies. The contractor shall protect all existing utilities to remain in place and shall maintain continuous service to the Owner, as applicable. Any damage to the utilities shall be corrected by the Contractor at his expense. The Contractor shall also be responsible for coordinating and/or relocating any utilities which must be relocated to accommodate the proposed construction.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Flowable fill shall meeting the requirements of Section 1047 of the Standard Specifications.
- B. All other materials shall be at the Contractor's option, subject to the approval of the Engineer or the Owner's Representative.

PART 3 - EXECUTION

3.1 CLEARING AND GRUBBING

- A. Clearing shall consist of the removal of all trees and shrubs, brush, down timber, rotten wood, heavy growth of grass and weeds, vines, rubbish, walks, roads, curbs, walls and foundations, existing utilities already abandoned, and all objectionable debris. All walls, foundations, slabs, pavements, curbs, and footings shall be removed to their full depth.
- B. Grubbing shall consist of the removal of stumps, roots, root mats, stumps, buried logs, and other debris within the project limits. The Contractor shall remove all stumps and root mats in their entirety and all buried logs and other debris from within building areas and from the limits of proposed drives and walks. Within proposed lawn areas, stumps, roots and debris shall be removed to a minimum depth of one foot below design road grade.
- C. Construction methods shall be in accordance with Section 101 of the Standard Specifications.

3.2 DISPOSAL OF REMOVED MATERIALS

- A. All timber and cleared materials shall become the property of the Contractor, and shall be disposed of by the Contractor. Burning of materials on site is prohibited.
- B. Pavement, base course, concrete, utilities, and other obstructions shall be removed from the site and shall be disposed lawfully. The Contractor shall provide evidence of the lawful disposal when requested by the Owner or the Owner's Representative.
- C. Existing building and site materials to be used crushed and reused for fill or backfill shall be subject to the approval of the geotechnical engineer who shall determine their suitability for structural and site backfill.

3.3 SALVAGED MATERIALS

- A. Materials listed to be salvaged for reuse shall be stored by the Contractor in such a manner to prevent damage to the material. Salvaged materials which are not reused shall be disposed of lawfully by the Contractor unless the Owner specifically requests to take possession of the material.

3.4 SITE DEMOLITION

- A. Remove walks, roads, curbs, walls and foundations, existing utilities already abandoned, and all objectionable debris. All walls, foundations, slabs, pavements, curbs, and footings shall be removed to their full depth.
- B. Procure all permits required for demolition and disposal. All debris shall be removed and disposed lawfully.
- C. Provide protection for the general public. Disconnect all utilities prior to demolition in areas where live utilities may be located.
- D. Coordinate utility work with utility companies. Disconnect all utilities prior to demolition in areas where live utilities may be located. Fill abandoned utilities with flowable fill where indicated on the Plans.

END OF SECTION

NOT FOR BID

SECTION 31 20 00 - EARTHMOVING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:
1. Filling and backfilling to attain indicated grades.
 2. Excavation, rough and finish grading.
 3. Furnishing and installing graded aggregate base course material for pavements, hot-mix patches and other structures.
 4. Undercut excavation and furnishing graded aggregate base course for undercut excavation.
 5. Furnishing excavation support systems, as required, including shoring and bracing.
 6. Excavation for trenches.
 7. Preparing topsoil stripped from the site and placing topsoil in locations requiring seeding or sodding.
- B. Definitions
1. Excavation: removal and disposal of all material encountered when establishing required grade elevations, including pavements and other constructions visible on the ground surface, and underground structures and utilities indicated to be demolished and removed, and unsuitable subgrade material.
 2. Unauthorized excavation: Removal of materials beyond specified subgrade elevations without approval of Engineer.

1.2 QUALITY ASSURANCE

- A. Requirements of Regulatory Agencies
1. All excavations shall be in compliance with Federal Occupational Safety and Health Act.
 2. Excavation work shall be in compliance with application requirements of other governing authorities having jurisdiction.
- B. Standards
1. Refer to the following sections in the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction, dated June 2021, latest revision. (Hereinafter referred to as the "Standard Specifications")
- | | |
|---------------|--|
| Section 202: | Excavation and Embankment |
| Section 207: | Structural Excavation and Backfill |
| Section 209: | Borrow |
| Section 301: | Graded Aggregate Base Course |
| Section 302: | Stone |
| Section 901: | Erosion, Sediment, and Stormwater Management |
| Section 902: | Pumping or Dewatering Practices |
| Section 1001: | Borrow |
| Section 1004: | Coarse Aggregate |

- Section 1005: Graded Aggregates
2. American Society for Testing and Materials (ASTM);
 - D-1556: Density of Soil in Place by the Sand-Cone Method.
 - D-698: Moisture Density Relations of Soils and Soil Aggregate Mixtures
 - D-2049: Relative Density of Cohesionless Soils.
 - D-2166: Unconfined Compressive Strength of Cohesive Soil.
 - D-2922: Density of Soil and Soil Aggregate in Place by Nuclear Methods (Shallow Depth)

1.3 SUBMITTALS

- A. Material Certification and delivery Slips for:
 1. Select Borrow
 2. Graded Aggregate Base Course

1.4 JOB CONDITIONS

- A. Existing Utilities
 1. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult the Utility Owner immediately for directions. Cooperate with the Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility Owner.
 2. Do not interrupt existing utilities serving facilities occupied and used by the Owner.
 3. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shut-off of services if lines are active.
- B. Use of Explosives: The use of explosives is not permitted unless approved by the Engineer.
- C. Protection of Persons and Property
 1. Barricade open excavations occurring as part of this work and post with warning signs as required to protect persons on the site.
 2. Protect trees, shrubs, lawns and other features remaining as part of final landscaping.
 3. Protect structures, utilities, sidewalks, pavements and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
 4. In the event of damage, immediately make all repairs and replacements to the approval of the Engineer at no cost to the Owner.
- D. Dust Control
 1. Use all means necessary to control dust on and near the work if such dust is caused by the Contractor's operations during performance of the work or if resulting from the conditions in which the Contractor leaves the site.
 2. Thoroughly moisten all surfaces as required to prevent dust being a nuisance to the public, neighbors and concurrent performance of other work on the site.
- E. Weather Conditions: Do not place, spread, or roll fill material during freezing, raining, or otherwise unfavorable weather conditions

PART 2 - PRODUCTS

2.1 GENERAL

- A. For approval of borrow materials for pavement, sidewalks, and civil structures, at least five (5) working days in advance of intention to import material, designate the proposed borrow area, and provide samples to prove the quality and suitability of the material.
- B. The use and approval of borrow material for structural fill will be the responsibility of the geotechnical engineer and the specification pertaining thereto.

2.2 ON-SITE FILL

- A. All on-site materials used for fill for pavement, sidewalk, and civil structures shall be acceptable to the Engineer and shall be minimally subject to the following requirements:
 - 1. Free from deleterious substances, stumps, brush, weeds, roots, sod, rubbish, garbage and matter that may decay.
 - 2. Free of large rocks or lumps that may create voids or prevent proper compaction.

2.3 BORROW FILL MATERIAL

- A. Free from deleterious substances, stumps, brush, weeds, roots, sod, rubbish, garbage and matter that may decay, and shall be Borrow Type "C" conforming to Section 1001 of the Standard Specifications. All excavated material which meets the requirements of Section 1001 of the Standard Specifications shall be used for borrow fill material.

2.4 TRENCH AND CIVIL STRUCTURE BACKFILL MATERIAL

- A. Backfill for civil structures shall conform to the requirements of Section 209 of the Standard Specifications.
- B. Backfill for trenches shall conform to the requirements of Section 209 of the Standard Specifications.
- C. All trench and civil structure backfill material shall meet the requirements of Section 1001 of the Standard Specifications for Borrow Type C backfill. All suitable excavated material, which meets the requirements of Section 1001 of the Standard Specifications shall be used for structure or trench backfill as far as practicable.

2.5 GRADED AGGREGATE BASE COURSE

- A. Graded Aggregate base course for bituminous and concrete pavements and other structures shall be Type "B" conforming to the requirements for Graded Aggregate in Section 301 and 1005 of the Standard Specifications.

2.6 GEOTEXTILE STABILIZATION FABRIC

- A. Geotextile stabilization fabric used for undercut excavation shall be a woven polypropylene geotextile designed for base course reinforcement and subgrade stabilization. Geotextile shall have a minimum tensile strength of 500 lbs, and shall be Mirafi HP565, or approved equal.
- B. Geogrid, where specified on the plan, shall be an integrally formed biaxial polypropylene geogrid with positive mechanical interlock. Geogrid shall have tensile strength of 6.0 kN/m at 2% strain, and an ultimate tensile strength of 19.2 kN/m. Geogrid shall be model BX1200 as manufactured by the Tensar International Corporation, or approved equal.

2.7 TOPSOIL

- A. Topsoil furnished from within or outside the project limits shall conform to Section 903 of the Standard Specifications except as modified by the following requirements.
 - 1. Topsoil shall be screened to not contain stones, lumps, roots or other objects larger than one-half inch in any dimension.
 - 2. Acid-Alkaline Range: pH 5.8 to 6.5.
 - 3. Free of pests, pest larvae, and matter toxic to plants.
 - 4. Maximum soluble salts: 500 ppm
 - 5. Free of viable Bermudagrass, quackgrass, Johnsongrass, nutsedge, poison ivy, Canada thistle, and other objectionable grassy or broadleaf weeds.
 - B. Topsoil Furnished from Outside Project Limits
 - 1. Gradation range:
 - Sand (2.00 mm to 0.05 mm) 40-80 percent
 - Silt (0.050 mm to 0.005 mm) 10-30 percent
 - Clay (0.005 mm and smaller) 10-30 percent
 - a. When one-half of the sand content is larger than 0.500 mm, the maximum sand content shall be seventy-five percent, and maximum clay content shall be fifteen percent.
 - b. Lower limits of silt and clay shall be flexible to extent that soils with minimum combined silt and clay content of twenty percent shall be satisfactory. However, if more than one-half of the sand is larger than 0.50 mm., then minimum clay content shall be fifteen percent, or the minimum combined silt and clay content shall be twenty-five percent.
 - 2. Organic content:
 - a. Minimum of 2.75 percent by weight.
 - b. If necessary, add peat at the rate necessary to attain minimum organic content.
- Additional payment will be made for topsoil furnished from outside of the project limits.

PART 3 EXECUTION

3.1 INSPECTION BY CONTRACTOR

- A. Examine the areas and conditions under which excavating, filling and grading are to be performed. No extra cost or time allowances will be granted for conditions existing and visible at the time of the bid opening.

3.2 PREPARATION

- A. Prior to commencement of work, establish location and extent of all utilities in the work areas. Maintain and protect, as required, existing utilities which pass through the work area.
- B. Prior to excavation in pavement areas, saw cut existing pavement in accordance with Section 762 of the Standard Specifications.

3.3 EXCAVATION

A. Unauthorized Excavation

Unauthorized excavation shall not be at the Owner's expense. Under roadways and pipes, fill unauthorized excavation by removing all loosened material and providing select material as required to attain a firm and unyielding subgrade and/or foundation and to attain required grade elevations.

B. Rock Excavation

Rock Excavation shall apply to the removal of bedrock and ledgerock which cannot be accomplished without blasting or the use of rippers. Use or disposal of such material. Excavation of material classified as "rock" shall conform to the requirements of Section 202 of the Standard Specifications.

- C. Rock Excavation for Structures and Benches shall apply to the removal, use, or disposal of all boulders or other detached stones having a volume of 1/3 cubic yard or more. Excavation of such material shall conform Section 202 of the Standard Specifications.

D. Undercut Excavation

- 1. If unsuitable bearing materials are encountered at the required subgrade elevations notify the Engineer immediately.
- 2. Unstable bearing materials shall be removed to a depth of one foot below subgrade. Place geotextile stabilization fabric and one foot of graded aggregate base course, Type B.
- 3. Base course shall be placed and compacted in six-inch lifts.

E. Stability of Excavations

- 1. Slope sides of excavations to comply with local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible because of space.
- 2. Maintain sides and slopes of excavations in a safe condition until completion of backfilling.

F. Shoring and Bracing

- 1. Provide materials for shoring and bracing, such as sheet piling, uprights, stringers and cross-braces, in good serviceable condition.

2. Establish requirements for trench shoring and bracing to comply with local codes and authorities having jurisdiction
3. Maintain shoring and bracing in excavations regardless of time period excavations will be open.
4. Brace, sheet, and support trench walls in such a manner that they will be safe and that the ground alongside the excavation will not slide or settle, and that all existing improvements of every kind, whether on public or private property, will be fully protected from damage.
5. In the event of damage to such improvements, immediately make all repairs and replacements necessary at no additional cost to the Owner.
6. Arrange bracing, sheeting and shoring so as to not place stress on any portion of the completed work until the general construction thereof has proceeded far enough to provide sufficient strength.
7. Exercise care in the drawing and removal of sheeting, shoring, bracing and timbering to prevent collapse and caving of excavation faces being supported.

G. Dewatering

1. Prevent surface water and subsurface or groundwater from flowing into excavations and from flooding the project site and surrounding areas.
2. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to the stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water from excavations.
3. Convey water removed from excavations and rainwater to collecting or runoff areas, which are not subject to erosion. Establish and maintain temporary drainage ditches and other diversions outside excavation limits for each structure. Do not use trench excavations as temporary drainage ditches.

H. Material Storage

1. Stockpile satisfactory excavated materials where directed until required for use as backfill or fill. Place, grade and shape stockpiles for proper drainage.
2. Locate and retain soil materials away from edge of excavations.
3. Dispose of excess soil material and waste materials as herein specified. Excavated material unsuitable for backfilling shall be kept separate from other materials excavated and disposed of. Materials suitable for backfilling shall not be disposed of until completion of filling or backfilling operations.

I. Excavation for Pavements and Pavement Patches

1. Cut surface under pavements to comply with cross-sections, elevations and grades as shown.

J. Excavation for Trenches

1. Dig trenches to the uniform width required for the particular item to be installed sufficiently wide to provide ample working room. Trench width to a point no less than two feet (2') above the outside top of pipe shall be the pipe outer diameter plus twenty-four inches (24").
2. Excavate trenches to the depth indicated or required. Carry the depth of trenches for piping to establish the indicated flow lines and invert elevations. Beyond the

building perimeter, keep bottoms of trenches for which elevations are not given sufficiently below finish grade to avoid freeze-ups.

3. Trenches for pipes shall not be opened more than the number of linear feet of pipe that can be placed and backfilled in one (1) day.
4. Grub roots and stumps within six inches (6") of outside surface of pipe bottom and sides to minimum depth of six inches (6") below grade. Backfill trenches with concrete where trench excavations pass within eighteen inches (18") of column or wall footings and which are carried below the bottom of such footings, or which pass under wall footings. Place concrete to the level of the bottom of adjacent footing.
5. Pipe bedding shall be as shown on the Plans.

K. Cold Weather Protection

1. Protect excavation bottoms against freezing when atmospheric temperature is less than thirty-five degrees (35°).

3.4 BACKFILL FILL AND COMPACTION

A. General

1. The project Inspector or Engineer shall be notified 24 hours in advance of any fill, backfill or compaction operations.
2. Place acceptable material in 8" lifts to required subgrade elevations.
3. Fills: Use suitable material (per Section 2.2 of this section) obtained from on-site excavation, except use borrow material when suitable on-site material is not available or when specified by the Engineer as shown on the Plans.
4. Backfilling: Use suitable material (per Section 2.2 of this section) obtained from on-site excavation, except use select backfill where indicated on Plans. Backfill to a height of two feet (2') above the top of pipe with earth free from stones, rock fragments, dirt clogs or frozen material greater than two inches (2") in largest dimension.
5. Do not provide additional off-site borrow material until all acceptable excavated materials on the site have been utilized in the work unless approved by the Engineer.
6. Place the various types of materials in the areas as designated on the Plans.

B. Backfill excavation as promptly as work permits, but not until completion of the following.

1. Inspection, testing, approval and recording locations of underground utilities.
2. Removal of concrete formwork.
3. Removal of shoring and bracing, and backfilling of voids satisfactory materials. Cut off temporary sheet piling driven below bottom of structures and remove in manner to prevent settlement of the structure or utilities, or leave in place if required.
4. Removal of trash and debris.
5. Permanent or temporary horizontal bracing is in place on horizontally supported walls.

C. Backfilling Prior to Approvals

1. Should any of the work be so enclosed or covered up before it has been approved, uncover all such work at no additional cost to the Owner.

2. After the work has been completely tested, inspected and approved, make all repairs and replacements necessary to restore the work to the condition in which it was found at the time of uncovering, all at no additional cost to the Owner.
- D. Ground Surface Preparation Prior to Filling
1. Remove all vegetation, debris, topsoil, unsatisfactory soil materials, obstructions and deleterious materials from existing ground surface to a depth of not less than four inches (4") and not more than six inches (6") prior to placement of fills. Plow, strip or break-up sloped surfaces steeper than one (1) vertical to four (4) horizontal to a depth of not less than six inches (6") so that fill material will bond with existing surface.
 2. 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.
- E. Placement and Compaction
1. Place backfill materials in layers not more than eight inches (8") in loose depth.
 2. Control soil compaction during construction providing minimum percentage of density specified for each area classification listed below.
 3. Pavement areas are defined, for the purpose of this Section as extending a minimum of five feet (5') beyond the building and/or pavement.
 4. Compact soil to not less than the following percentages of maximum dry density for soils which exhibit a well-defined moisture density relationship determined in accordance with ASTM D-1557; and not less than the following percentages of relative density determined in accordance with ASTM D-2049, for soils which will not exhibit a well-defined moisture-density relationship.
 - a. Lawn or Unpaved Areas: Compact top six inches (6") of subgrade and each layer of backfill or fill material at 90 percent (90%) maximum dry density.
 - b. Walkways: Compact top six inches (6") of subgrade and each layer of backfill or full material at 95 percent (95%) maximum dry density.
 - c. Pavement Areas: Compact top twelve inches (12") of subgrade and each layer of backfill or fill material at 95 percent (95%) maximum dry density.
 - d. Base Course Materials: Compact each layer of base course material to 95 percent (95%) of maximum dry density.
 - e. Trench Stabilization Materials: Compact each layer of material to 95 percent (95%) of maximum dry density.
 5. Moisture Control:
 - a. 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, to prevent free water appearing on surface during or subsequent to compaction operations.
 - b. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.
 - c. Soil material that has been removed because it is too wet to permit compaction may be stockpiled or spread and allowed to dry. Assist drying by discing, harrowing or pulverizing until moisture content is reduced to a satisfactory value.

- d. Moisture condition fills materials to within 3 percent (3%) of the optimum moisture. Fill that is so wet that it is unstable under compaction equipment shall be dried and re-compacted to achieve a stable fill.
6. Puddling or jetting will not be permitted.
7. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice, or other unsuitable materials.
8. Place backfill and fill material evenly adjacent to structures, to be 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.
9. Compact backfill to height of two feet (2') above top of pipe using approved flat-faced mechanical tampers.

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.

B. Grading Outside Building Lines

Grade areas adjacent to building lines to drain away from structures and to prevent ponding. Finish surfaces free from irregular surface changes, and as follows:

1. Lawn or unpaved areas: Finish area to receive topsoil to within not more than 0.10 feet 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 feet above or below the required subgrade elevation.
3. Pavement: Shape surface of areas under pavement line, grade and cross-section, with finish surface not more than 1/2 inch above or below the required subgrade elevation. All topsoil and other unsuitable material shall be removed and replaced with suitable backfill.

C. Compaction

1. After grading, compact subgrade surfaces to the depth and percentage of maximum density for each area classification.

D. Treating after Grading

1. After grading is completed, permit no further excavating, filling or grading.
2. Use all means necessary to prevent erosion of freshly graded areas during construction and until such time as permanent drainage and erosion control measures have been installed.

E. Subgrade Preparation

1. All subgrade preparation shall be performed in accordance with the applicable Sections of the Delaware Department of Transportation Standard Specifications except as may be modified by this Specification Section.
2. Subgrades for paving shall be firm and unyielding when proof-rolled in accordance with Section 202 of the Standard Specifications.

3.6 GRADED AGGREGATE BASE COURSE

A. General

1. Base Course consists of placing graded aggregate base course material in layers of specified thickness over subgrade surface to support pavements, pavement patches and structures, as shown on Plans.
2. Provide Base Course in accordance with Section 301 of the Standard Specifications, except as otherwise modified by this Specification Section.

B. Grade Control

1. During construction, maintain lines and grades including crown and cross-slope of base course.

C. Placing

1. Place base course material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. Maintain optimum moisture content for compacting base course material during placement operations.
2. When a compacted base course is shown to be eight inches (8") or less, place material in a single layer. When shown to be more than eight inches (8") thick, place material in equal layers, except no single layer shall be more than eight inches (8") in thickness when compacted.
3. Spread, shape and compact all base course material deposited on the subgrade during the same day.

3.7 FIELD QUALITY CONTROL

- A. Quality control testing during construction. Allow testing service to inspect and approve subgrades and fill layers before further construction work is performed.
- B. If subgrade or fills which have been placed are below specified density, provide additional compaction and testing at no expense to the Owner. This shall include compaction and testing at areas initially tested and at other locations as directed.

3.8 MAINTENANCE

A. Protection of Graded Areas

1. Protect newly graded areas from traffic and erosion. Keep free of trash and debris.
2. Repair and establish grades in settled, eroded and rutted areas to specified tolerances.

B. Reconditioning Compacted Areas

1. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape and compact to required density prior to further construction.

3.9 DISPOSAL OF EXCESS AND WASTE MATERIALS

- A. Remove waste materials, including excess and unacceptable excavated material, trash and debris, and dispose of it off the Owner's property.

3.10 TOPSOILING

A. Preparation

1. Verify that clearing, earthwork, grading and other preceding work affecting ground surface have been completed and that the area to be topsoiled is cleared, shaped and dressed.
2. Preparation of Topsoil Subsoil
 - a. Shape and dress area to be topsoiled. This work includes grading to required lines and elevations; removal of all stones, clods, lumps one inch or larger in any dimension; removal of all wires, cables, pieces of concrete, tree roots, and debris or other unsuitable material.
 - b. Do not proceed with installation of topsoil until this work has been approved.

B. Installation

1. Place in even layers that will produce the minimum compacted thickness as indicated on the Plans.
2. If quantity of topsoil obtained from stripping is insufficient for the project requirements, provide required topsoil from approved sources located outside project limits at no additional expense to the Owner.
3. Screen to remove stones, stump roots and other objects larger than one-half inch in any dimension from graded topsoil surface.

C. Maintenance

1. Immediately before establishment of ground cover, re-topsoil and regrade areas, which become eroded or otherwise disturbed.
2. Perform all maintenance work in accordance with the Specifications without additional compensation.
3. Maintenance period to extend until installation of ground cover.

D. Clearing

1. Immediately clean spills, soil, and conditioners on paved and finished areas.
2. Haul and dispose of topsoil in excess of the quantity required for the project off site.
3. Dispose of protective barricades and warning signs at termination of maintenance period.

END OF SECTION

SECTION 31 25 00 - EROSION AND SEDIMENT CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Provide temporary soil erosion and sediment control measures in accordance with the Plans and Contract Documents.

1.2 QUALITY ASSURANCE

A. Standards

Except as modified by governing codes and by the Contract Documents, comply with the applicable provisions and recommendations of the following:

1. Delaware Erosion and Sediment Control Handbook, latest revision.
2. Delaware Department of Transportation Standard Specifications for Highways and Bridges, dated June 2021 (hereinafter referred to as the "Standard Specifications").

B. Design Criteria

1. The primary objective of this specification is to control soil erosion to the maximum extent practicable.
2. The temporary control provisions contained herein shall be coordinated with permanent erosion control features to the extent practical to assure effective and continuous erosion control throughout the construction and post-construction period.
3. The erosion control measures described herein shall be continued until the construction is complete and all disturbed areas are fully stabilized.
4. Wherever construction exposes work which is subject to erosion, erosion control features or other work to be completed within such areas shall follow as soon after exposure as practicable.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Temporary mulches shall conform to Section 908 of the Delaware Department of Transportation Standard Specifications for Bridges and Highways.
- B. Temporary grass mixtures shall be as shown on the Plans, or in the absence of plan information, shall conform to the Section 908 of the Standard Specifications.
- C. Temporary structural Erosion Control measures shall conform to the requirements of the Delaware Erosion and Sediment Control Handbook and the Delaware Department of Transportation Standard Specifications.
- D. Erosion control matting and blankets shall conform with the Delaware Erosion and Sediment Control Handbook requirements for soil stabilization matting (SSM) I and II, as indicated on

the Plans. Matting shall be composed of 100% agricultural straw (minimum 0.5 pounds per square yard) or 100% wood excelsior fiber (0.8 pounds per square yard) with a single or double netting of either photo-degradable or bio-degradable material. SSM-I shall be North American Green S75, American Excelsior Curlex I, or approved equal. SSM-II shall be North American Green S150, American Excelsior Curlex II, or approved equal.

PART 3 - EXECUTION

3.1 CONSTRUCTION REQUIREMENTS

- A. Vegetative stabilization shall be used on graded or cleared areas, which are subject to erosion for a period of 14 days or more.
- B. All temporary erosion control measures shall be installed in accordance with the Delaware Erosion and Sediment Control Handbook.
- C. Erosion control matting shall be installed in accordance with the manufacturer's written instructions, the requirements of the Delaware Erosion and Sediment Control Handbook, and the details on the Plans.
- D. In the event of conflict between these requirements and pollution control laws, rules, or regulations of other federal or state agencies, the more restrictive laws, rules, or regulations shall apply.
- E. The Contractor shall be responsible for maintaining all soil erosion and sediment control measures in an acceptable and functional manner. The Contractor shall remove all temporary measures after all other construction is complete, final restorations installed, and all disturbed areas have been adequately stabilized.

END OF SECTION

SECTION 32 05 23 - CONCRETE SIDEWALKS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Sawcut and remove existing brick and concrete sidewalk, ramps, and pads as shown on the plan, marked in the field, or as directed by the Engineer.
- B. Patch or provide new concrete sidewalk, ramps, and pads in areas designated on Plans, marked in the field, or as directed by the Engineer.
- C. Place Graded Aggregate Base Course below proposed concrete sidewalks.
- D. Construct accessible curb ramps with detectable warning surfaces.
- E. Provide stamped and colored concrete in locations shown on the Plans.

1.2 STANDARDS

- A. The quality of materials and performance of work specified in this section shall be in accordance with the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction, dated June 2021, latest revision (hereinafter referred to as the "Standard Specifications").

Section 301: Graded Aggregate Base Course

Section 705: P.C.C. Sidewalk, Pedestrian Connections, and Sidewalk Detectable Warning Surface

Section 762: Saw Cutting and Butt Joints

Section 1022: Portland Cement Concrete

1.3 SUBMITTALS

- A. Certificates: All deliveries of concrete shall be accompanied by delivery slips.
- B. Submit concrete mixtures, source of supply, and product data in accordance with the conditions of the Contract.
- C. Submit product data for color and hardening additives.
- D. Submit one complete set of color chips representing the manufacturer's full range of available colors and texture. Final colors to be selected by the Landscape Architect

1.4 ENVIRONMENTAL REQUIREMENTS

- A. Allowable Concrete Temperatures
 1. Cold weather: 60 degrees Fahrenheit. (18° C) when discharged from the mixer.
 2. Hot weather: Maximum concrete temperature is 80 degrees Fahrenheit. (30° C).

- B. Do not place concrete during rain, when atmospheric temperature is at or below 36 degrees Fahrenheit (2° C), or when conditions are otherwise unfavorable.

1.5 PROTECTION

- A. Protect concrete from pedestrian and vehicular traffic until concrete has been sufficiently cured.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Concrete
 - 1. Use concrete developing a compressive strength of 3,000 p.s.i. at twenty eight (28) days.
 - 2. Use air-entrained concrete.
- B. Cement aggregates, water and air-entrainment methods and materials conforming to Section 1022 of the Standard Specifications.
- C. Joint filler: Pre-formed expansion joint material, conforming to Section 800.06 of the Standard Specifications.
- D. Curing compound: White pigmented liquid, conforming to AASHTO M 148 for Type 2, Class A or B.
- E. Vapor barrier: Where called for on Plans shall be 6 mil. polyethylene.
- F. Surface detectable warning system for curb ramps shall comply with Section 705 of the Standard Specifications.
- G. Colored Concrete
 - 1. Provide a decorative concrete colorizer that leaves a solid color surface enhanced with flakes of accent colors exposed through the use of a deactivator. Color system shall be Gem-Tex as manufactured by Proline Decorative Concrete Systems, or approved equal. Deactivator shall be manufactured by the same company that provides the color system.
 - 2. Color system shall be durable, resistant to ultraviolet light, streak-free, and slip resistant.

PART 3 - EXECUTION

3.1 REMOVING EXISTING SIDEWALK

- A. All portions of existing concrete sidewalk to be removed shall be isolated from pavements, curb, or buildings to remain by saw cutting or by the presence of an existing expansion joint. Care shall be exercised by the Contractor to ensure that no damage occurs to any elements to remain and any damage to items to remain shall be replaced or repaired by the Contractor at no additional cost to the Owner.
- B. Concrete shall be broken up by an approved power breaking machine. All concrete removed shall be taken off the project site and disposed of lawfully.

3.2 PREPARATION FOR NEW SIDEWALK

- A. Excavate subgrade and set forms so that finished sidewalk conforms to lines and grades shown on Plans.
- B. Prepare sidewalk subgrade as specified in Section 705 of the Standard Specifications.
- C. Verify that earthwork is completed to correct line and grade.
- D. Verify that forms conform to line, grade and dimensions shown on Plans.
- E. Check that subgrade is smooth, compacted and free of excessive moisture.
- F. Do not commence work until conditions are satisfactory.

3.3 CONSTRUCTION METHODS

- A. Concrete sidewalks and aprons shall be constructed in accordance with the requirements of Section 705 of the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction.
- B. Use vibration or tamping to consolidate the rapid set concrete patching material. Work material into saw cuts, extending beyond the corners of the repair area. Strike-off and shape the material to match the surrounding concrete.
- C. Construct accessible curb ramps and pedestrian connections in accordance with the details shown on the Plans and the requirements of Section 705 of the Standard Specifications.

3.4 COLORED CONCRETE

- A. Coloring and deactivating agents shall be applied in accordance with the manufacturer's written instructions.
- B. The contractor who applies the color system shall be experienced in the application methods and procedures, and shall provide evidence of at least three (3) such previous successful applications.

END OF SECTION

SECTION 32 12 16 - ASPHALT PAVING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:
1. Milling existing pavements.
 2. Patching pavement, including removal of existing pavement and installation of bituminous concrete base course patch.
 3. Surface preparation, and installation of bituminous concrete base course (BCBC).
 4. Surface preparation, and installation of Type B, binder course pavement, where applicable.
 5. Installation of Type C wearing surface course for pavement patching, and for overlay of existing bituminous pavement including patched and repaired areas.
 6. Pavement markings

1.2 STANDARDS

- A. The quality of materials and performance of work specified in this section shall be in accordance with the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction, dated June 2021, latest revision (hereinafter referred to as the "Standard Specifications").
1. Section 401: Bituminous Pavement
 2. Section 402: Bituminous Paving Materials, Patching
 3. Section 760: Pavement Milling
 4. Section 817: Pavement Markings
 5. Section 1011: Tack Coat
 6. Section 1014: Asphalt Materials Production

1.3 DEFINITIONS

- A. Subgrade: Surface upon which pavements will be constructed.
- B. Base Course: That portion of the pavement cross section consisting of graded aggregate base course or bituminous concrete depth.

1.4 QUALITY ASSURANCE

- A. Bituminous concrete producer shall be regularly engaged in the production of hot-mix, hot-laid bituminous concrete, and shall be approved by the Delaware Department of Transportation or the Pennsylvania Department of Transportation.

1.5 SUBMITTALS

- A. Job mix formula and source of supply.
- B. Provide copies of delivery slips at the end of each working day.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Materials and mixtures shall comply with the following sections of Delaware Department of Transportation Standard Specifications. All bituminous concrete paving shall be obtained from a DelDOT approved plant.

2.2 PAVING MATERIALS AND MIXTURES

- A. Graded Aggregate Base Course
 - 1. Materials: Section 301 and 1005 of the Standard Specifications.
- B. Bituminous Concrete Pavement shall meet the requirements of the following sections of the Standard Specifications:
 - 1. Materials: Section 401.
 - 2. Mixture: Section 1014
- C. Emulsified Asphalt: Section 1016 of the Standard Specifications
- D. Coarse Aggregate: Section 1004 of the Standard Specifications
- E. Tack Coat: Meeting the requirements of Section 1017 of the Standard Specifications.

2.3 JOB MIX FORMULA REQUIREMENTS

- A. Provide job mix formulas for each required bituminous concrete mixture as specified in Section 401 of the Standard Specifications.
- B. Submit for approval prior to beginning paving operations.

2.4 MIX DESIGN AND CONTROL REQUIREMENTS

- A. The design and control requirements for all paving mixtures shall conform to Section 401 of the Standard Specifications.

2.5 SAMPLES AND TESTING

- A. Methods and rates of sampling bituminous mixtures shall conform to Section 1014 of the Standard Specifications with the following exceptions:
 - 1. Sampling shall be performed by the producer's quality control technician.
 - 2. For small scale projects where it is possible to attain the minimum lot size specified, a total of five (5) samples shall be taken at random for each type of mix specified, per each day's production.
- B. Testing of bituminous concrete mixtures to determine the quantity of bitumen, gradation of aggregate, and conformance to mix design requirements shall be as specified in Section 401 of the Standard Specification.

- C. Submit results of tests on forms signed by producer's quality control technician.

2.6 PREPARATION OF MIXTURES

- A. The preparation of all bituminous mixtures shall conform to Section 1014 of the Standard Specifications.

2.7 PAVEMENT MARKINGS

- A. All paint shall be of materials approved by the Delaware Department of Transportation per Sections 817 and 1071 of the Standard Specifications for reflectorized Epoxy Paint.
- B. Thermoplastic material, where shown on the Plan or required by the City of Wilmington, shall meet the requirements of Sections 817 and 1071 of the Standard Specifications.

PART 3 - EXECUTION

3.1 GENERAL

- A. The method of construction including bituminous concrete plant and equipment, bituminous concrete pavers, vehicles for transporting bituminous mixtures, rollers and all construction methods shall conform to Section 401 of the Standard Specifications except as modified by the Supplemental Requirements below.

3.2 PAVEMENT MILLING

- A. Construction methods for pavement milling shall conform to Section 760 of the Standard Specifications.

3.3 PAVEMENT PATCHING

- A. Construction methods for patching pavement shall conform to Sections 401 and 402 of the Standard Specifications. A milling machine may be used for pavement and base course removal.

3.4 PROOF ROLL

- A. Proof roll subgrade surfaces using heavy, rubber-tired rollers, or loaded dump truck in accordance with Section 202 of the Standard Specifications. Proof roll in the presence of the Owner's Representative.
 1. Subgrades shall be firm and unyielding.
 2. Compaction shall be showing deflection and instability.
- B. Notify the Engineer or the Inspector of unsatisfactory conditions.
- C. Do not begin paving work until any such unsatisfactory conditions have been corrected.

3.5 SURFACE PREPARATION

- A. Earth and Base Course Surface

1. Remove loose and foreign material from compacted subgrade surface immediately before application as required.
2. Use power broom or blowers and hand brooming as required.
3. Do not displace subgrade material.

B. Existing Pavement Surfaces

1. Remove loose and foreign material from existing pavement surfaces immediately before application of paving
2. Use self-propelled mechanical sweepers. Supplement with hand brooming as required.
3. Pay particular attention to cleaning of gutter lines and outer edges of pavement areas.
4. Remove all weeds, grass or other vegetative matter growing in pavement areas, particularly along joints and curbs.

C. Minor Patching

1. Existing pavement surfaces: Fill in depressions, and patch pavement in overlay areas that are not marked out for base repairs.

3.6 TACK COAT

- A. Apply to cleaned surfaces of all pavements to be overlaid or slurry seal coated.
- B. Apply to cleaned surfaces of newly constructed base pavement if coated with dust, dirt, foreign materials in sufficient amount to prevent bond with surface course.
- C. Apply to edges of paving where base repairs are to be made.
- D. Apply tack coat material at temperatures, specified in Section 401 of the Standard Specifications.
- E. Apply at rate of 0.05 to 0.15 gallons per square yard immediately prior to placing pavement.
- F. Apply tack coat by brush to contact surfaces of pavement cold joints, curbs, gutters, manholes, and other structures projecting into or abutting asphalt concrete pavement.
- G. Allow surfaces to dry until material is in a condition of tackiness to receive pavement.
- H. Take precautions to ensure tack coat is not applied to exposed surfaces of curbs or other exposed surfaces. Tack coat so applied shall be removed by Contractor at no additional cost to Owner.

3.7 GENERAL SURFACE REQUIREMENTS

- A. Test finished surface of each bituminous concrete course for smoothness using a ten (10) foot straightedge.
- B. The straightedge shall have projections on the bottom at each end, either built-in or firmly attached, so that it is supported six (6") inches above the pavement surface at the ends. It shall be free from warp and deflection, and furnished by the Contractor without additional compensation.
- C. Check surfaced areas at intervals and in directions specified.

- D. Check surfaces for pavement smoothness immediately after initial compaction, and correct variations by removing or adding material as may be necessary. Then rolling shall be continued as specified.
- E. Immediately after final rolling and while the pavement is still hot, the smoothness of the course shall be checked again and all projections or depressions exceeding the specified tolerances shall be corrected by removing defective work and replacing it with new surface course as specified. Portions of the surface otherwise unsatisfactory shall be replaced.
- F. Finished surfaces shall be free of all roller marks, ridges and voids.

3.8 FIELD QUALITY CONTROL

- A. Taking of pavement cores and testing for the determination of conformance to control air voids and pavement thickness shall be performed in accordance with Section 401 of the Standard Specifications.
- B. When required per the General or Special Provisions, the Contractor shall employ and pay for the services of an Independent Testing Laboratory acceptable to the Engineer to perform additional field quality control sampling and testing when initial tests indicate work does not comply with the Contract Documents. All sampling and testing shall be performed as specified in section 401 of the Standard Specifications.
- C. Areas of pavement removed for field quality control testing, shall be replaced by the Contractor as follows:
 - 1. Clean debris from core area. Cut all exposed pavement edges vertical.
 - 2. Apply tack coat to exposed surfaces before installing replacement pavement.
 - 3. Fill core area with surface course mixture for the full depth of the core.
 - 4. Compact and grade mixture; seal required area with tack coat; and apply thin layer of sand over tack coat.

3.9 PAVEMENT MARKINGS

- A. Paint equipment and installation shall conform to Section 817 of the Standard Specifications.
- B. Application of Thermoplastic materials, where required, shall conform to Section 817.3.5 of the Standard Specifications.
- B. All markings shall comply with the Manual on Uniform Traffic Control Devices, the Delaware Manual on Traffic Controls for Street and Highway Construction and Maintenance, the Delaware State Fire Prevention Regulations, and the Delaware State Accessibility Board.

END OF SECTION

SECTION 32 13 13 - CONCRETE PAVING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Sawcut and remove existing concrete paving, sidewalk, ramps, and pads as shown on the plan, marked in the field, or as directed by the Engineer
- B. Provide new concrete paving and pads in areas designated on the Plans, marked in the field, or as directed by the Engineer.
- C. Place Graded Aggregate Base Course below proposed concrete paving and pads

1.2 STANDARDS

- A. The quality of materials and performance of work specified in this section shall be in accordance with the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction, dated June 2021 (hereinafter referred to as the "Standard Specifications").

Section 301: Graded Aggregate Base Course
Section 501: Portland Cement Concrete Pavement
Section 762: Saw Cutting and Butt Joints
Section 1022: Portland Cement Concrete Production

1.3 SUBMITTALS

- A. Certificates: All deliveries of concrete shall be accompanied by delivery slips.

1.4 ENVIRONMENTAL REQUIREMENTS

- A. Allowable Concrete Temperatures
 1. Cold weather: 60 degrees Fahrenheit. (18° C) when discharged from the mixer.
 2. Hot weather: Maximum concrete temperature is 80 degrees Fahrenheit. (30° C).
 3. Maintain temperatures of not less than 50 degrees Fahrenheit surrounding the concrete pavement for a curing period of five (5) calendar days following placement on the concrete.
- B. Do not place concrete during rain, when atmospheric temperature is at or below 36 degrees Fahrenheit. (3° C), or when conditions are otherwise unfavorable.

1.5 PROTECTION

- A. Protect concrete from pedestrian and vehicular traffic until concrete has been sufficiently cured.
- B. Protect the concrete from freezing or other thermal damage.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Concrete
 - 1. Use concrete developing a compressive strength of 4,500 p.s.i. at twenty-eight (28) days.
 - 2. Use air-entrained concrete.
- B. Cement, aggregates, water and air-entrainment methods and materials shall conform to Section 1022 of the Standard Specifications for Class A concrete.
- C. Joint filler: Pre-formed expansion joint material, conforming to Section 1042 of the Standard Specifications.
- D. Curing compound: White pigmented liquid, conforming to AASHTO M 118 for Type 2, Class A or B.
- E. Vapor barrier: Where called for on Plans shall be 6 mil polyethylene.
- F. Spalled areas shall be removed, or when acceptable to the Engineer, repaired with a pre-blended, pre-packaged cement-based mortar requiring only the addition of potable water. The material shall not contain any chlorides or lime other than the amounts contained within the hydraulic composition. The concrete repair material shall have a minimum strength of 5,000 psi after 28 days. Concrete repair material shall be as manufactured by Five Star Products, Inc., or approved equal.

2.02 GRADED AGGREGATE BASE COURSE

- A. Graded aggregate based course shall meet the requirements of Section 1005 of the Standard Specifications for Type B aggregate based course.

PART 3 EXECUTION

3.01 REMOVING EXISTING PAVING

- A. All portions of existing concrete paving to be removed shall be isolated from pavements, curb, or buildings to remain by sawcutting or by the presence of an existing expansion joint. Care shall be exercised by the Contractor to ensure that no damage occurs to any elements to remain and any damaged items to remain shall be replaced or repaired by the Contractor at no additional cost to the Owner.
- B. Concrete shall be broken up by an approved power breaking machine. All concrete removed shall be taken off the project site and disposed of lawfully.

3.02 PREPARATION FOR NEW PAVING AND PADS

- A. Excavate to subgrade and set forms so that the finished paving conforms to the lines and grades shown on the Plans.

- B. Prepare paving subgrade as specified in Section 501 of the Standard Specifications.
- C. Verify that earthwork is completed to correct line and grade.
- D. Verify that forms conform to proposed line, grade and cross section.
- E. Check that subgrade is smooth, compacted and free of frost and excessive moisture.
- F. Do not commence work until conditions are satisfactory.

3.03 CONSTRUCTION METHODS

- A. Concrete paving shall be constructed in accordance with the requirements of Section 501 of the Standard Specifications.
- B. Use vibration or tamping to consolidate the rapid set concrete patching material. Work material into saw cuts, extending beyond the corners of the repair area. Strike off and slope the material to match the surrounding concrete.

3.04 TESTING

- A. Subgrade shall be compaction tested to ensure compliance with the standards of Section 31200 of these Specifications
- B. Test the compressive strength of the concrete in accordance with Section 501 of the Standard Specifications.
- C. The contractor shall be responsible to provide all required testing including the use of third-part testers.

END OF SECTION

SECTION 32 14 13 - CONCRETE UNIT PAVING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Furnish materials, labor, transportation, services, and equipment needed to furnish and install architectural concrete pavers as indicated on the Drawings and as described herein.
- B. Provide concrete and mortar base for the pavers as shown the Drawings.

1.2 STANDARDS

A. Performance Requirements

- 1. Compressive strength at the time of delivery shall not be less than 7,000 psi per ASTM C-140.
 - 2. Water absorption shall not be greater than 6% per ASTM C-956.
 - 3. Flexural strength shall not be less than 800 psi per ASTM C-293.
 - 4. The paver shall be subjected to freeze/thaw tests per Section of ASTM C-67 and shall have no breakage greater 2% loss in dry weight when subject to 100 cycles of freeze/thaw.
- B. Sizing dimensions shall not differ by more than 1/16 inch in width, height, length, or thickness. Each unit shall conform to a true plane and not differ by more than 1/16 inch in either concave or convex warpage.

1.3 SUBMITTALS

- A. Submit manufacturer's data sheets on each product to be used, including preparation instruction, installation methods, storage, and handling requirements and recommendations.
- B. Submit layout drawings of each paved area showing the pattern of pavers, the pavers needing cutting, setting bed methods in each area, and details of the setting beds.
- C. Submit one complete set of color chips representing the manufacturer's full range of available colors and textures. Final color to be selected by the Landscape Architect.
- D. Field-Constructed Mockup
 - 1. Provide mockup of the eight foot (8') by eight foot (8') color paver area detailed on the Drawings.
 - 2. Show the typical arrangement of the pavers and any special features for expansion joints and adjacent work. Provide the range of color, texture, and workmanship to be expected in the completed work.
 - 3. Mockups are not part of the actual work and shall not be incorporated into the final installation.
 - 4. Notify the Landscape Architect one (1) week in advance of each mockup construction.
 - 5. Obtain the Architect's acceptance of the mockup before proceeding with the installation.

6. Retain mockups during construction as a standard for judging installed pavers. Do not alter or destroy the mockup until directed by the Landscape Architect.

- E. Submit product data for the latex mortar to be used for the setting bed and joints.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: All products covered under this Section shall be produced by a single manufacturer with a minimum of ten (10) years production experience.
- B. Installer Qualifications: Installer shall have a minimum of three (3) years specialized experience with the specified product or with similar concrete pavers.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Architectural concrete pavers shall be stretch wrapped in rows and banded on pallets delivered in unopened packaging with legible manufacturer identification, including size, quantity, color, and manufacture date.
- B. Protect pavers during shipment, storage, and construction against damage. Store on pallets in a dry location. Cover with a waterproof membrane to protect from contact with materials which could cause staining or discoloration.
- C. Store cementitious materials off of the ground, under cover, in a dry location.
- D. Handle pavers to prevent chipping, breakage, scoring, or other damage. Damaged pavers shall not be used in construction. Replace any damaged pavers at the contractor's sole expense.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Concrete architectural pavers shall be as manufactured by Wausau Tile, Wausau, Wisconsin: (800) 388-8728, wausautile.com, or approved equal.
- B. Product line, size, shape, and color shall be as indicated on the Drawings.
- C. Portland cement shall meet the requirements of ASTM C-150. Aggregates shall meet ASTM-C33 specifications, cleaned and properly graded to size. Aggregate shall be blended to meet individual product requirements. Color shall be factory-blended.

2.02 BLENDED MATERIALS

A. Mortar Setting Bed Materials

1. Portland Cement: ASTM C-150, Type I or II.
2. Hydrated Lime: ASTM C-207, Type S
3. Sand: ASTM C-144
4. Latex Additive: Acrylic resin water emulsion, serving as a replacement for part or all of gaging water, of type specifically recommended by the latex-additive manufacturer for

use with field-mixed Portland cement and aggregate mortar bed, and not containing a retarder.

- B. Latex cement grout shall comply with ANSI A-118.7, sanded. Polymer type shall be acrylic resin in liquid-latex for addition to pre-packaged dry grout mix.
- C. Water: Potable.
- D. Concrete Base:
 - 1. Concrete shall comply with Section 812 of the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction, latest addition, for Class B Concrete.
 - 2. Reinforcing fabric shall be galvanized welded wire complying with ASTM A-1064.
- E. Graded aggregate base course shall meet the requirements of Section 1001 of the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction, latest addition, for Type B graded aggregate.

PART 3 EXECUTION

3.01 PREPARATION

- A. Excavate to subgrade and set forms so that the finished product conforms to the lines and grades shown on the Plans.
- B. Prepare, compact, and proof-roll the subgrade to obtain a firm and unyielding base.
- C. Moisten, spread, and compact the stone base material. Compact with at least two passes of a 10-ton vibratory roller until there is no visible movement of the base. The contractor shall verify that the elevations of the base are correct prior to placing bedding materials.

3.02 INSTALLATION

- A. Construct concrete base in accordance with Section 812 of the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction, latest addition.
- B. After concrete has cured sufficiently, apply mortar-bed bond coat over surface of concrete subbase before placing the setting bed.
- C. Place mortar bed over bond coat. Spread and screed mortar bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.
- D. Install architectural pavers into mortar bed and set firmly. Tamp into bedding to ensure adequate contact with the mortar bed. Coat the underside of each paver with latex cement mortar.
- E. Grout pavers in strict compliance with the manufacturer's directions and instructions.

- F. Remove, scrub, and wash clean mortar stains and all other types of soiling from exposed paver surfaces.

3.04 PROTECTION

- A. Protect installed pavers from damage or staining until the completion of the project.
- B. Remove and replace any pavers which are loose, chipped, broken, stained, or otherwise damaged, or if units do not match adjoining units as intended. Provide new units to for all removed, damaged, stained, or improperly installed units.

3.05 CLEANING AND SEALING

- A. Wash the entire surface with phosphate free, pH balanced soap. Rinse thoroughly and allow to dry thoroughly.
- B. Apply a coat of concrete sealer per the manufacturer's written instructions.

END OF SECTION

NOT FOR BID

SECTION 32 16 13 - CONCRETE CURB

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Remove and dispose off site existing concrete or bituminous curb as shown on the Plans, marked in the field, or as directed by the Engineer.
- B. Install new poured Portland cement concrete curb in the locations designated on the Plans, marked in the field, or as directed by the Engineer.

1.2 STANDARDS

- A. The quality of materials and performance of work specified in this section shall be in accordance with the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction, dated June 2021 (hereinafter referred to as the "Standard Specifications").

Section 701: PCC Curb, Integral PCC Curb, PCC Monolithic Medians, and Curb Openings
Section 1022: Portland Cement Concrete Production

- B. Curb installed in the City of Wilmington public right-of-way shall be twenty (20) inches deep and shall be built in accordance to the City of Wilmington Department of Public Works standards.

1.3 SUBMITTALS

- A. Certificates: All deliveries of concrete shall be accompanied by delivery slips.

1.4 ENVIRONMENTAL REQUIREMENTS

- A. Allowable Concrete Temperatures
 1. Cold weather: 60 degrees Fahrenheit. (18° C) when discharged from the mixer.
 2. Hot weather: Maximum concrete temperature is 80 degrees Fahrenheit. (30° C).
- B. Do not place concrete during rain, when atmospheric temperature is at or below 36 degrees Fahrenheit (2° C), or when conditions are otherwise unfavorable.

1.5 PROTECTION

- A. Protect new concrete curb from traffic for a minimum of seven (7) days.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Concrete

1. Use concrete developing a compressive strength of 3,000 p.s.i. at twenty-eight (28) days.
 2. Use air-entrained concrete.
- B. Cement, aggregates, water and air-entrainment methods and materials conforming to Section 1022 of the Standard Specifications for Class B concrete.
- C. Joint filler: Pre-formed expansion joint material, conforming to Section 1042 of the Standard Specifications.
- D. Curing compound: White pigmented liquid, conforming to AASHTO M 148 for Type 2, Class A or B.
- E. Bituminous Joint Sealant: Conforming to the requirements of section 1042 of the Standard Specifications:

PART 3 EXECUTION

3.01 PREPARATION

- A. When encountered, cut existing pavements vertically with a sharp tool on a straight line prior to excavating for curb. Cut shall be made twelve inches (12") to twenty-four inches (24") beyond the limits of excavation, and maintained straight and neat, or re-cut and dressed as required.
- B. Excavate subgrade and set forms so that finished curb conforms to required lines and grades.
- C. Prepare curb subgrade as specified in Section 701 of the Standard Specifications.
- D. Verify that earthwork is completed to correct line and grade.
- E. Verify that forms conform to proposed line, grade and curb cross section.
- F. Check that subgrade is smooth, compacted and free of frost and excessive moisture.
- G. Do not commence work until conditions are satisfactory.

3.02 PERFORMANCE

- A. Method of curb construction shall conform with Section 701 of the Standard Specifications
 1. Install 1/2-inch wide expansion joints at equal intervals, not to exceed forty feet (40'). Install additional expansion joints where curb abuts structures, and install expansion joints or curb breaker where curb abuts sidewalk. Fill expansion joints with joint filler, 1/2-inch thick. Insert joint filler 1/4-inch from the top and face of curb.
 2. Construct contraction joints (transverse joints) at 10' intervals, except where shorter sections are necessary for closures; but no section shall be less than four feet (4').
 3. Finish concrete surfaces of curb to match existing adjacent curbs. Curb cross section shall be as shown on the Plans.

END OF SECTION

**SECTION 323119
DECORATIVE METAL FENCES AND GATES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Aluminum swing gate at service yard.
- B. Egress gate at service yard.

1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete.

1.03 REFERENCE STANDARDS

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to start of work of this section; require attendance by affected installers.

1.05 SUBMITTALS

- A. Product Data: Submit manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
- B. Shop Drawings:
 - 1. Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, gates, and schedule of components.
 - 2. Foundation details, concrete design mix and reinforcing schedule.
- C. Manufacturer's Qualification Statement.
- D. Installer's Qualification Statement.
- E. Manufacturer's Warranty.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum five years documented experience.
- B. Installer Qualifications: Experienced with type of construction involved and materials and techniques specified and approved by fence manufacturer.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Store materials in a manner to ensure proper ventilation and drainage. Protect against damage, weather, vandalism and theft.

1.08 WARRANTY

- A. Finish: 10 years.

PART 2 PRODUCTS

2.01 ALUMINUM GATE:

- A. Description: Double-leaf manual swing gate at service yard.
- B. Size: 24'-0" width x 8'-0" height.
- C. Finish: Powder-coat meeting AAMA 2604, color to be selected from manufacturer's standard range.
- D. Extrusions: 6063-T5 aluminum alloy or better.
- E. Horizontal rails: U-shaped, flat, size as required by manufacturer for size of gate.
- F. Pickets: 3/4" x 3/4" square, spaced 2" O.C, with pressed point tops.
- G. Hardware:

1. Truss cable: as required by manufacturer for size of gate.
 2. Hinges: welded to gate uprights.
 3. Latch: welded to gate uprights, for padlock.
- H. Posts: Square, size as required by manufacturer for size of gate.
- I. Manufacturers:
1. Ameristar Perimeter Security, USA; Montage II Classic: www.ameristarfence.com
 2. Ideal Aluminum Products; Double swing industrial estate gate: www.ideal-ap.com
 3. Ultra Aluminum Manufacturing Inc; Commercial Drive Gate: www.ultrafence.com/
 4. Or approved equal..
 5. Substitutions: See Section 016000 - Product Requirements.

2.02 EGRESS GATE SYSTEM

- A. Description: Pre-hung ornamental gate system, including gate, posts, jamb frame, infill, mullions and hardware.
- B. Manufacturer:
1. Ameristar Perimeter Security, USA; Exodus Egress Gate System: www.ameristarfence.com.
 2. Or approved equal. Substitutions: See Section 016000 - Product Requirements.
- C. Ornamental picket infill: 1" square x 14 ga. [0.075 inch] tubing for pickets, spaced 5" o.c. max.
1. Infill frame shall be 12 ga [0.105 inch] steel.
 2. Perforated metal mesh shall be 3/16" round x 1/2" x 18 ga [0.048 inch] steel.
- D. Gate: 1.75" thick x 14 ga [0.075 inch] steel reinforced structural design with 4" plate reinforced hinge mounting.
- E. Hinges: stainless steel five knuckle bearing hinges with non-removable pin and stainless steel fasteners.
- F. Gate jamb frame: fully welded, 3" x 12 ga [0.105 inch] square tubing for main jamb, 1" square gate stop, and strike mounting block, and gate stop bumpers.
1. Installation: flange mount.
- G. Posts: 4 inch square, 12 ga [0.109 inch], direct bury.
1. Concrete for post foundations. See Section 033000.
- H. Removable mullion (double leaf gates): 1980 Removable Mullion
- I. Fabrication:
1. Pre-drilled to accept appropriate hardware set. Fabricate infill frames as a single unit. Frame shall be of welded construction inset with mesh filler, with attachment to gate frame by means of security fasteners.
 2. Gate shall be pre-assembled.
 3. Mounted gate threshold with fasteners allowing for placement below grade or removal after gate installation.
 4. Each gate leaf shall have clear opening (from gate stop to face of gate open to 90 degrees) of 41".
- J. Hardware:
1. General:
 - a. Gate hardware to consist of exterior rated devices.
 - b. Gate and hardware to be pre-assembled prior to shipping.
 2. Exit Devices: Von Duprin 99 Series, rim mounted.
 3. Closers: LCN 4040XPSRI, parallel arm.
 4. Pulls: Rockwood VRT16.
 5. Cylinders: See Section 0871000.
 6. Keying: Key to building masterkey system.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Coordinate with adjacent masonry and concrete work.
- B. Do not begin installation until substrates have been properly prepared.
- C. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.02 PREPARATION

- A. Clean surfaces thoroughly prior to installation.

3.03 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Space gate posts according to the manufacturers' drawings, dependent on standard out-to-out gate leaf dimensions and gate hardware selected.
 - 1. Base type and quantity of gate hinges on the application, weight, height, and number of gate cycles.
 - 2. Identify the necessary hardware required for the application on the manufacturer's gate drawings.
 - 3. Provide gate hardware by the manufacturer of the gate and install in compliance with manufacturer's recommendations.

3.04 TOLERANCES

- A. Maximum Variation From Plumb: 1/4 inch.
- B. Maximum Offset From Indicated Position: 1 inch.
- C. Minimum Distance from Property Line: 6 inches.

3.05 CLEANING

- A. Leave immediate work area neat at end of work day.
- B. Clean jobsite of excess materials; scatter excess material from post hole excavations uniformly away from posts. Remove excess material if required.
- C. Clean fence with mild household detergent and clean water rinse well.
- D. Touch up scratched surfaces using materials recommended by manufacturer. Match touched-up paint color to factory-applied finish.

3.06 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair, or replace damaged products before Date of Substantial Completion.

SECTION 32 90 00 - PLANTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS AND STANDARDS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This section includes the following:

1. Trees
2. Shrubs
3. Plants
4. Topsoil
5. Stakes and guys
6. Landscape fabric.

- B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Section 31100: Site Clearing
2. Section 31200: Earthmoving

1.3 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

- B. Product certificates signed by manufacturers certifying that their products comply with specified requirements.

1. Manufacturer's certified analysis for standard products.
2. Analysis for other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.
3. Label data substantiating that plants, trees, shrubs, and planting materials comply with specified requirements.

- C. Qualification certificates for firms and persons to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of Engineers and owners, and other information specified.

- D. Planting schedule indicating anticipated dates and locations for each type of planting and coordination with other site work for approval.

- E. Maintenance instructions recommending procedures to be established by Owner for maintenance of landscaping during an entire year. Submit before expiration of required maintenance periods.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who has completed landscaping work similar in material, design, and extent to that indicated for this Project and with a record of successful landscape establishment.
 - 1. Installer's Field Supervision: Installer shall maintain an experienced full-time supervisor on the Project site during times that landscaping is in progress.
- B. Provide quality, size, genus, species, and variety of trees and shrubs indicated on the Plans, in accordance with the applicable requirements of ANSI Z60.1 "American Standard for Nursery Stock", latest edition.
- C. Landscape Architect may inspect trees either at place of growth or at site before planting, for compliance with requirements for genus, species, variety, size, and quality. Landscape Architect retains the right to further inspect trees for size and condition of balls and root systems, insects, injuries and latent defects, and to reject unsatisfactory or defective material at any time during progress of work. Contractor shall remove rejected trees from project site.
- D. Do not make substitutions of plant materials. If required landscape materials not obtainable, submit proof to the Landscape Architect, together with proposal for use of equivalent material.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in containers showing weight, analysis, and name of manufacturer. Protect materials from deterioration during delivery and while stored at site.
- B. Trees and Shrubs: Deliver freshly dug trees and shrubs. Do not prune before delivery, except as approved by Engineer. 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 natural shape. Provide protective covering during delivery. Do not drop trees and shrubs during delivery.
- C. Handle balled and burlapped stock by the root ball.
- D. Deliver trees, shrubs, and plants after preparations for planting have been completed and install immediately. If planting is delayed more than 6 hours after delivery, set planting materials in shade, protect from weather and mechanical damage, and keep roots moist.
 - 1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
 - 2. Do not remove container-grown stock from containers before time of planting.
 - 3. Water root systems of trees and shrubs stored on site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.

1.6 PROJECT CONDITIONS

- A. Utilities: Determine location of above grade and underground utilities and perform work in a manner which will avoid damage. Hand excavate, as required. Maintain grade stakes until

removal is mutually agreed upon by parties concerned. The Contractor shall be responsible for the location and protection of all utilities and for repair of any utilities damaged by Contractor's work.

- B. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Landscape Architect before planting.

1.7 COORDINATION AND SCHEDULING

- A. Coordinate installation of planting materials during normal planting seasons for each type of plant material required.

1.8 PLANT MATERIAL QUANTITIES

- A. Quantities on the plant list are approximate, the Contractor shall supply plants in quantities as shown on the drawings.

1.9 WARRANTY

- A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

- B. Special Warranty: Warrant the following living planting materials for a period of two years after date of Substantial Completion, against defects including death and unsatisfactory growth, except for defects resulting from neglect or abuse by Owner, abnormal weather conditions unusual for warranty period, or incidents that are beyond Contractor's control.

1. Trees.
2. Shrubs.
3. Plants.

- C. Remove and replace dead planting materials immediately unless required to plant in the succeeding planting season.
- D. All replacements shall be plants of the same kind, size, and quality as originally specified.
- E. Replace planting materials that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
- F. Replaced plants shall be furnished, planted, mulched, and watered as part of the warranty.
- G. A limit of one replacement of each plant material will be required, except for losses or replacements due to failure to comply with requirements.

1.10 TREE AND SHRUB MAINTENANCE

- A. Maintain trees and shrubs by pruning, cultivating, watering, weeding, fertilizing, restoring planting saucers, tightening and repairing stakes and guy supports, 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. Maintain trees and shrubs for the following period.

1. Maintain trees and shrubs until condition is approved by Landscape Architect and Owner, and Owner has reviewed and accepted maintenance instructions provided by the Contractor.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Furnish nursery-grown trees and shrubs conforming to 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, sunscald, injuries, abrasions, and disfigurements.
- B. Provide trees and shrubs of sizes and grades conforming to ANSI Z60.1 for type of trees and shrubs required. Trees and shrubs of a larger size may be used in accordance to Engineer with a proportionate increase in size of roots or balls.
- C. Label at least one (1) tree and shrub of each variety and caliper with a securely attached, waterproof tag bearing legible designation of botanical and common name.

2.2 SHADE AND FLOWERING TREES

- A. Shade trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, free of branches to about 50% of their height, of height and caliper indicated, conforming to ANSI Z70.1 for type of trees required.
- B. Small trees: Small upright or spreading type, branched or pruned naturally according to species and type, and with relationship of caliper, height, and branching recommended by ANSI Z60.1.
- C. Provide balled and burlapped trees except where indicated.
 1. Container-grown trees will be accepted in lieu of balled and burlapped trees subject to meeting ANSI Z60.1 limitations for container stock.

2.3 DECIDUOUS SHRUBS

- A. Form and Size: Deciduous shrubs with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape and height of shrubs.
- B. Provide balled and burlapped trees except where indicated.
 1. Container-grown trees will be acceptable in lieu of balled and burlapped deciduous trees subject to meeting ANSI Z60.1 limitations for container stocks.

2.4 CONIFEROUS EVERGREENS

- A. Form and Size: Normal-quality, well-balanced, coniferous evergreens, of type, height, spread, and shape required, conforming to ANSI Z60.1
- B. Provide balled and burlapped coniferous evergreens.
 - 1. Container-grown coniferous evergreens will be acceptable in lieu of balled and burlapped coniferous evergreens subjected to meeting ANSI Z60.1 limitations for container stock.

2.5 BROADLEAF EVERGREENS

- A. Form and size: Normal-quality, well-balanced, broadleaf evergreens, of type, height, spread, and shape required, conforming to ANSI Z60.1.
- B. Provide balled and burlapped broadleaf evergreens.
 - 1. Container-grown broadleaf evergreens will be acceptable in lieu of balled and burlapped broadleaf evergreens subject to meeting ANSI Z60.1 limitations for container stock.

2.6 REQUIREMENTS FOR BALLED AND BURLAPPED STOCK

- A. Where indicated to be balled and burlapped, provide trees dug with firm, natural ball of earth in which they are grown free of noxious weed matter.
- B. Provide ball size of not less than diameter and depth recommended by ANSI Z60.1 for type and size of tree required. Increase ball size or modify ratio of depth to diameter as required to encompass fibrous and feeding root system necessary for full recovery of trees subject to unusual or non-typical conditions of growth, soil condition, or horticultural practice.
- C. No balled and burlapped plant will be accepted if the ball is cracked or broken either before or during the process of planting.
- D. Wrap and tie earth ball as recommended by ANSI Z60.1 for size of balls required. Drum-lace balls with a diameter of 24" or greater.

2.7 TOPSOIL AND BACKFILL

- A. Topsoil shall be as specified in Section 312000 of these Specifications.
- B. Backfill in planting holes shall be as specified on the Plans.

2.8 MULCH

- A. Mulch shall be double shredded, hardwood bark, uniform in size and free of foreign matter.

2.9 STAKES AND GUYS

- A. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, redwood, or pressure-preservative-treated softwood, free of knots, holes, cross grain, and other defects, 2 by 2 inches (50 by 50 mm) by length indicated, pointed at one end.

- B. Flexible strapping: ASTM A-641 (ASTM A 641 M), Class 1, galvanized-steel wire, 2-strand, twisted, 0.106 inch (2.7 mm) in diameter.
- C. Hose Chafing Guard: Reinforced rubber or plastic hose at least 2 inch (13 mm) in diameter, black, cut to lengths required to protect tree trunks from damage.

2.10 LANDSCAPE FABRIC

- A. Provide landscape fabric for planting beds where designated on the Plans. Landscape fabric shall be 100% spunbonded polypropylene with UV inhibitors. The fabric shall have a minimum unit weight of 1.9 ounces per square yard, a minimum tensile strength of 73 pounds, and a minimum puncture strength of 23 pounds. Fabric shall be black have a minimum permittivity of 3.0 sec^{-1} . Landscape fabric shall be Typar Professional Landscape Fabric or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive landscaping for compliance with requirements and/or conditions affecting performance of work of this Section. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 EXCAVATION FOR TREES AND SHRUBS

- A. Pits and Trenches: Excavate with vertical sides. Loosen half of subsoil in bottom of excavation.
 - 1. Balled and Burlapped Trees and Shrubs: Approximately 3 times as wide as ball diameter and equal to ball depth.
 - 2. Container-Grown Trees and Shrubs: Loosen and mix soil with rototiller or shovel.
- B. Obstructions: Notify Engineer if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
- C. Drainage: Notify Engineer if subsoil conditions evidence unexpected water seepage or retention in tree or shrub pits.

3.3 PLANTING TREES AND SHRUBS

- A. Set balled and burlapped stock plumb and in center of pit or trench with top of ball raised above adjacent finish grades as indicated.
 - 1. Place stock on undisturbed subgrade.
 - 2. Remove burlap and wire baskets from tops of balls and from sides, but do not remove from under balls. Remove pallets, if any, before setting.
 - 3. Place soil around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately 2 backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill.

- B. Set container-grown stock plumb and in center of pit or trench with top of ball raised above adjacent finish grades as indicated.
 - 1. Carefully remove containers so as not to damage root balls.
 - 2. Place stock on undisturbed subgrade.
 - 3. Place soil around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately backfilled, water thoroughly before placing remainder of backfill.
- C. Dish and tamp top of backfill to form a 3-inch (75-mm) high mound around the rim of the pit. Do not cover top of root ball with soil.

3.4 TREE AND SHRUB PRUNING

- A. Prune, thin, and shape new trees and shrubs according to standard horticultural practice. Prune trees to retain required height and spread. Unless otherwise directed by Engineer, do not cut tree leaders; remove only injured or dead branches from flowering trees. Prune shrubs to retain natural character. Shrub sizes indicated are size after pruning.

3.5 TREE AND SHRUB GUYING AND STAKING

- A. Guying and Staking: Guy and stake trees exceeding 14 feet (4.2 m) and more than 3-inch (75-mm) caliper unless otherwise indicated. Securely attach no fewer than 3 guys to stakes 30-inches (760 mm) long, driven to grade. Attach flags to guy wire, 30 inches (760 mm) above finish grade.
- B. Contractor shall remove stakes 4 to 6 months after planting.

3.6 CLEANUP AND PROTECTION

- A. During landscaping, keep pavement clean and work area in an orderly condition.
- B. Protect landscaping from damage due to landscape operations, operations by other contractors and trades, and trespassing. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged landscape work as directed.

3.7 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris and legally dispose of it off the Owner's property and in accordance with the environmental specifications.

END OF SECTION

SECTION 32 92 00 - TURF AND GRASSES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide lime and permanent seeding in the areas shown on the Plans for:
 - 1. Newly graded athletic fields
 - 2. Restoration of existing grass areas disturbed by Contractor's operations
 - 3. Stabilization of unpaved areas.
- B. Furnish and install sod in the locations shown on the Plan or marked in the field.
- C. Mulch seeded areas.
- D. Water and maintain sod, seeded areas, and lawn during the establishment and maintenance periods.

1.2 STANDARDS

- A. The quality of materials and performance of work specified in this section shall be in accordance with the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction, dated June 2021, latest revision (hereinafter referred to as the "Standard Specifications").

Section 908: Soil Stabilization Practices

1.3 SUBMITTALS

- A. Submit product data for seed and for sod, including mix components stating the botanical and common name and percentage by weight of each species and variety, and percentage purity, germination, and weed seed. Identify the source and supplier of seed and turfgrass sod.
- B. Certificates for Delivered Material
 - 1. Seed producer's certified analysis of composition, purity, and germination of seed mixture, dated within nine (9) months of sowing.
 - 2. Manufacturer's certified chemical and physical composition analysis for ground limestone.
- C. Delivery Slip
 - 1. Accompany each delivery of seed, ground limestone, and fertilizer with delivery slip showing the product weight.
- D. Test Reports
 - 1. Submit results of test report for pH analysis of soil, and when ground limestone is required, the total amount of magnesium and calcium oxides required.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Deliver all dry materials in accordance with manufacturer's printed instructions, and in such manner as to protect from moisture.
- B. Store and handle material in accordance with manufacturer's printed instructions, and in such manner as to protect from moisture.
- C. Sod shall be stripped, delivered, and laid within a period of 36 hours. Sod stripped and delivered but not laid within 36 hours will be inspected by the Owner or Engineer, and must be approved prior to placing.

1.5 JOB CONDITIONS

- A. Existing Conditions: Perform seeding only after preceding work affecting finished surfaces is completed.
- B. Environmental Requirements
 - 1. Plant seed on unfrozen soil. Soil shall be in friable condition at the time of seeding.
 - 2. Do not perform seeding when wind exceeds 15 mph.
 - 3. Seed during the periods listed on the Plans.
- C. Protection: Restrict pedestrian and vehicular traffic from seeded areas after planting to end of the establishment period.

1.6 SOD INSTALLER QUALIFICATIONS

- A. Sod shall be obtained from a source acceptable to the Engineer.
- B. Sod shall be installed by a qualified landscape installer whose work has resulted in successful lawn establishment. Evidence of five successful sod installations similar to that proposed in size and scope shall be provided to the Engineer.

PART 2 - PRODUCTS

2.1 SEED MIXTURE

- A. Seed mixture shall be as shown on the Plans, or in the absence of a mixture shown on the plan, shall be the seed mixture specified in Section 908 of the Standard Specifications for Permanent Grass Seeding - Subdivisions.
- B. Use clean, dry, new crop seed, delivered to the site in unopened packages in accordance with the Delaware Code. Seed shall be at least 98% pure seed with 0% weed seed.

2.2 TURFGRASS SOD

- A. Turfgrass sod shall be Certified Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with the Turfgrass Producers

International's "Specifications for Turfgrass Sod Materials" in its "Guideline Specifications for Turfgrass Sodding."

- B. Furnish viable sod of uniform density, color, and texture, strongly rooted from high quality seed of known origin, and capable of vigorous growth and development when planted.
- C. Turfgrass Species: Grass species shall be substantially similar to the seed mixture shown on the Plans and described herein for seeding, and shall be suitable for usage in sun and shade.
- D. Sod shall be free of objectionable grassy and broadleaf weeds. Sod shall not contain any of the following weeds: common Bermuda grass, quack grass, Johnson grass, poison ivy, nutsedge, nimblewill, Canadian thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, or bromegrass. Sod shall be reasonable free of thatch, diseases, nematodes, and soil-borne insects.
- E. All sod must display the official State Certification tags of the state from which the sod originated. The same shall apply to all sod shipped intra-state with prior inspection and tagging through the Delaware State Department of Agriculture.

2.3 TOPSOIL

- A. topsoil shall conform to Section 31200 of these Specifications.

2.4 GROUND LIMESTONE

- A. Limestone shall be ground agricultural grade conforming to Section 908 of the Standard Specifications.

2.5 MULCH

- A. Straw mulch shall be unrotted small grain straw shall be relatively free of weeds, and shall be free of noxious weeds such as timothy, Johnsongrass, and quackgrass.
- B. Hydraulically Applied Mulch
 1. Wood fiber mulch shall consist of specially prepared wood that has been processed to a uniform state, is packaged for sale as a hydraulic mulch for use with hydraulic seeding equipment, and consists of a minimum of 70% virgin or recycled wood fiber combined with 30% paper fiber and additives.
 2. Blended fiber mulch shall consist of any hydraulic mulch that contains greater than 30% paper fiber. The paper shall be processed to a uniform fibrous state and packaged for sale as a hydraulic mulch for use with hydraulic seeding equipment.
 3. A bonded fiber matrix (BFM) shall consist of long strand, specially prepared wood fibers that have been processed to a uniform state held together by a water resistant bonding agent. BFM's shall contain no paper, but may contain shall percentages of synthetic fibers to enhance performance.
 4. All components of the hydraulically applied mulches shall be pre-packaged by the manufacturer to assure material performance.
- C. Erosion control blankets and turf reinforcement matting shall be as shown on the Plans, or if not on the Plans, shall meet the requirements of Section 908 of the Standard Specifications.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Check that clearing, soil preparation and preceding work affecting ground surface is completed.
- B. Verify that soil is unfrozen and within allowable moisture content.
- C. Do not start until conditions are satisfactory.
- D. When soil to be seeded or sodded has a pH value of less than 5.8, evenly spread ground limestone, which is dry and free flowing, over area to be seeded at rate that will change soil pH value to 6.5. Thoroughly mix limestone into upper 3 to 4 inches of soil by discing, harrowing, or other approved method.
- E. Water dry soil at least 24 hours prior to seeding to obtain a loose friable seed bed.
- F. Before applying seed, remove all stones, rocks, lumps, roots, wires, closs and other objects measuring one-half inch or larger in any dimension.
- G. The areas to be sodded shall be shaped and finished to the lines and grades indicated on the Plans, and the surface loosened prior to placing the seed. The Contractor shall water the ground before the sod is placed.

3.2 APPLICATION

- A. Broadcast half of seed with mechanical seeder.
- B. Broadcast remaining half of seed at right angle to first seeding pattern, using same broadcast method.
- C. Apply seed at the rate specified on the Plans.
- D. Cover seed to depth of 1/2 inch by raking or other approved method.
- E. Roll seeded area with roller weighing maximum of 150 pounds per foot of width.
- F. Water seeded area until water penetrates to a depth of 3 to 4 inches.

3.3 SODDING

- A. Provide machine-cut sod with maximum deviation from width and length being 5%.
- B. Lay the first row of sod in a straight line with subsequent rows placed parallel and tight. Lateral joints shall be staggered. Do not stretch or overlap sod. Shape sod to form the line and contour of play areas or infield areas. Edge sod to form clean line.
- C. Lightly water sod during installation to prevent drying.

- D. The Contractor shall water the sod immediately after placement to a depth sufficient so that the underside of the new sod pads and soil immediately below the sod are thoroughly wet. The sod shall be kept moist until growth is established. All sod which is shrinking or burning, or where discoloration is evident shall be removed and replaced.

3.4 PROTECTION

- A. Erect temporary signs and barriers to protect seeded areas from pedestrian and vehicular traffic.

3.5 LAWN ESTABLISHMENT

A. Watering

1. Keep soil moist during seed germination period and during lawn establishment.
2. Method of watering shall provide equal distribution and coverage to all areas seeded.
3. Continue watering during establishment period to promote healthy grass stand.
4. Keep sod moist at all times for two weeks following installation. Watering may be required several times a day. Continue watering until sod is well rooted and lawns established.
5. Contractor may use water supplied by the School District through the existing supply and irrigation systems. Any supplemental water needed to maintain viable seed, lawn, or sod shall be provided by the Contractor at no additional cost. All water used shall be potable.

- B. Re-lime and reseed all seeded areas which become eroded or otherwise disturbed; or which require mowing of weedy areas in order to establish acceptable turf.

- C. Re-lime, and reseed spots larger than one square foot not having uniform stand of grass practically weed free, and not containing plants in reasonable proportion to the various kinds of seed in the grass seed mixture.

- D. Perform all lawn establishment work in accordance with the specifications without additional compensation.

- E. Establishment and maintenance period shall extend until acceptance of the project.

3.6 CLEANUP AND PROTECTION

- A. Immediately clean spills, soil, and debris on paved and finished surface areas.

- B. Erect barricades and warning signs as required to protect newly planted areas from traffic. Maintain barricades throughout the maintenance period and remove after lawn establishment.

- C. Remove debris and excess materials from project site.

- D. Dispose of protective barricades and warning signs at termination of lawn establishment period.

3.7 MULCHING

- A. Straw mulch shall be applied at the rate of 70 to 90 pounds per 1,000 square feet.

- B. Hydraulically Applied Mulch

1. Hydraulic mulches shall be applied with a viable seed and at the manufacturer's recommended rates.
 2. Apply the product to stable slopes. Do not apply to saturated soils or if precipitation is anticipated within twenty-four hours.
 3. Minimum curing temperature is forty degrees (40°F).
- C. Mulch shall be anchored immediately following application by crimping or tracking, or through the use of biodegradable netting or erosion control blankets.

3.8 LAWN MAINTENANCE

- A. Maintain seeded areas until grass is well established and exhibits vigorous growth condition for a minimum of two cuttings. Maintain grass height of three inches. Do not cut more than one third of the grass blade at each mowing. Perform the first mowing when seedlings are approximately four inches long. Do not mow when the grass is wet.
- B. Maintain sodded areas to establish a healthy, well-rooted, evenly colored, viable lawn area, free of weeds, open joints, bare areas, and surface irregularities. Maintain grass height of three inches. Do not cut more than one third of the grass blade at each mowing. Perform the first mowing when the grass exceeds four inches long. Do not mow when grass is wet.
- C. Establishment and maintenance period to extend until the acceptance of the project.

END OF SECTION

SECTION 33 11 00 - WATER UTILITY PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Furnish and install ductile iron water pipe, fittings, and appurtenances as shown on the Plans and described herein.
- B. All water mains, fittings, taps, valves, and fire hydrants shall be supplied, installed, disinfected, and tested in accordance with the requirements of the City of Wilmington Department of Public Works and the Delaware Department of Health.
- C. Coordinate with the City of Wilmington Department of Public Works for service connections and to determine the scope of services to be performed by the City of Wilmington.

1.2 STANDARDS

- A. City of Wilmington Department of Public Works Standards and Specifications. All contractors shall be approved by the Wilmington Department of Public Works.
- B. American Water Works Association
 1. AWWA C900
 2. AWWA C151
 3. AWWA C104
 4. AWWA C110
 5. AWWA C111

1.3 SUBMITTALS

- A. All pipe and fittings shall be inspected and tested at the place of manufacture as required by the AWWA standards referenced in the specification. Where applicable, provide the Engineer with two copies of certifications from each manufacturer stating the product was inspected as required, and that the test results comply with AWWA standards.
- B. Submit manufacturers' product data for pipe, fittings, valves, hydrants, gaskets, and irrigation equipment.
- C. All manufacturers shall validate other than by certification, the ductility of each length of pipe by an Underwriters Laboratory approved method. All P.V.C. pipe is to have Underwriters Laboratory approval.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Ductile Iron Pipe
 1. Shall conform to AWWA C-151, Class 52, and shall be manufactured in eighteen or twenty foot nominal lengths.

2. All ductile iron pipe for water mains shall be cement-lined, 1/8-inch thick, in accordance with AWWA C104 and seal coated inside.
 3. Use Push-on joints, conforming to AWWA C151 and AWWA C111, except where mechanical joints are indicated on the Plans.
- B. Pipe Fittings
1. Shall be ductile iron fittings conforming to AWWA C110, with minimum pressure rating of 250 p.s.i.
 2. Fittings shall be cement-lined, 1/8-inch thick, in accordance with AWWA C104 and seal-coated inside.
 3. Fittings shall have mechanical joints.
- C. All water valves, valve boxes, and fire hydrants shall meet the requirements of the City of Wilmington Department of Public Works.

PART 3 - EXECUTION

3.1 INSPECTION AND QUALITY OF PIPE

- A. Before being lowered into the trench, each pipe shall be carefully inspected, and those not meeting the Specifications shall be rejected and either destroyed or removed from the work within ten (10) hours. No pipe shall be laid except in the presence of the Owner's designated representative. The Owner's designated representative may order the removal and relaying of any pipe not so laid.
- B. The Contractor shall carefully examine all pipe and special castings before placing the same in the trench. Any pieces which are broken or show evidence of cracks or fractures shall be rejected by the Contractor. Such inspection shall carry with it the responsibility on the part of the Contractor for the removal at the Contractor's own expense of all pipe, special castings, and appurtenances, incorporated in the work, and which under test are found to be cracked or otherwise defective.

3.2 INSTALLATION

- A. Excavation and backfill for pipes shall conform to Specification Section 312000 - Earthwork and shall be as shown on the Plans.
- B. All piping shall be installed in a neat and workmanlike manner. All piping shall be installed to accurate lines and grades and shall be supported as shown, specified, or as necessary. Where temporary supports are used, they shall be sufficiently rigid to prevent shifting or distortion of the pipe. Suitable provision shall be made for expansion where necessary.
- C. No defective pipe or fitting shall be laid or placed, and any piece discovered to be defective after having been laid shall be removed and replaced by a sound and satisfactory piece by the Contractor at the Contractor's own expense.
- D. Every pipe and fitting shall be cleared of all dirt and other debris before being installed and shall be kept clean until accepted in the completed work.

- E. No pipes shall be laid in fill or other unsuitable material, in a wet trench, or in the same trench with another pipe or other utility unless so noted on the drawings. A minimum eighteen-inch (18") clearance shall be maintained between the outside surface of pipe and outside surface of other existing pipes and structures. When this clearance cannot be maintained, contact the Engineer for instructions prior to proceeding with the pipe installation.
- F. No direct contact between pipes and structures at crossings will be permitted. Pipes in place shall not be worked over or walked on until covered by backfill well tamped in place to a depth of twelve inches over the pipe.
- G. Minimum cover over water mains shall be three and one half feet (3-½').
- H. The interior of all pipes shall be thoroughly cleaned of all foreign material before being lowered into trench. Pipes shall be kept clean during laying operations by means of plugs or other approved methods.
- I. Gas, storm sewer, and sanitary sewer lines shall have right-of-way and water mains shall be installed to avoid the same. If conflicts occur between proposed water lines and other utilities, the water lines shall be dropped below the conflicting utility to attain the proper clearance.
- J. Brace all plugs as required to prevent leakage or blowout during testing.
- K. All newly placed pipes shall be pressure tested, sterilized, and cleaned in accordance with City of Wilmington Department of Public Works, the Delaware Department of Health, and NFPA Standards and Specifications.
- L. All construction

3.3 PIPING SUPPORTS

- A. The Contractor shall furnish and install all supports necessary to hold the piping and appurtenances in a firm substantial manner at the lines and grades indicated on the drawings or specified. Bends, tees, and other fittings buried in the ground shall be backed up with concrete placed against undisturbed earth where firm support can be obtained. If the soil does not provide firm support, then suitable bridle rods, clamps, and accessories to brace the fitting properly shall be provided. Such bridle rods, etc., shall be coated thoroughly with an approved bituminous paint after assembly, or, if necessary, before assembly. This work shall include bracing plugs to prevent leakage or blowout during testing.

3.4 HANDLING AND CUTTING PIPE

- A. Handle and lay pipe and fittings to avoid damage to the pipe, scratching or marring machined surfaces, and abrasion of the coating or lining. Pipe cuts shall be made using an abrasive wheel, rotary wheel cutter, guillotine pipe saw, milling wheel saw, or other method approved by the Engineer. Grind cut ends and rough edges smooth. For push-on connections, bevel cut all ends.

3.5 ASSEMBLING PIPE

- A. Clean ring groove and bell socket prior to inserting rubber gasket seal. Properly seat gasket; make sure it faces proper direction.
- B. Clean bell and spigot ends of pipe. Lubricate spigot end of pipe and rubber gasket.
- C. Hold pipe securely and in proper alignment when joining.
- D. Join pipe so that reference mark on spigot end, if provided by manufacturer, is flush with end of bell.
- E. Join pipe in strict accordance with manufacturer's printed installation procedures.

3.6 PROTECTION

- A. Protect all finished work. Joints once made and disturbed shall be subjected to immediate rejection. It shall therefore be the duty of the Contractor to avoid the slightest movement in completed work, while in the act of laying the pipe, in backfilling, or in the passage of workmen up and down the trench. At all times during which pipe is not being laid, the end of the pipe shall be sealed with a tight fitting plug. In no case will the drainage of trench water through a completed pipe be permitted.
- B. All curves, bends, tees, hydrants and ends of pipe shall be securely blocked with socket clamps, yokes, or concrete blocking to prevent movement. At the end of a line or turn, where provision has been made for future extension or connection, fittings shall be furnished with lugs and anchored by means of socket clamps or yokes.

3.7 ADAPTORS

- A. When it is necessary to join pipes of different types the Contractor shall furnish and install the necessary adaptors. Adaptors shall have ends conforming to the above Specifications for the appropriate type of joint to receive the adjoining pipe. When adaptors join two classes of pipe, the adaptors may be the lighter class.

3.8 CLEANING AND TESTING

- A. All waterlines shall be fully cleaned, disinfected, and tested in accordance with the City of Wilmington Department of Public Works standards and requirements, or the NFPA standards in the case of fire system lines, before being accepted by the Owner.

END OF SECTION

SECTION 33 31 00 - SANITARY SEWERAGE

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Furnish and install polyvinyl chloride (PVC) gravity sewer and appurtenances as shown on the Plans and described herein.
- B. Furnish and install manholes, connect existing pipes to manholes, and connect proposed pipes to existing manholes as shown on the Plans or as directed by the Engineer.
- C. Adjust manhole tops as shown on the Plans.

1.2 STANDARDS

- A. American Society for Testing and Materials (ASTM)
 - 1. ASTM D-3034: Polyvinyl Chloride (PVC) Sewer Pipe and Fittings
 - 2. ASTM F-679: Polyvinyl Chloride (PVC) Large-Diameter Gravity Sewer Pipe and Fittings
 - 3. ASTM 1785: Schedule 40 Polyvinyl Chloride (PVC) pipe.
- B. City of Wilmington Department of Public Works Standards and Specifications. All contractors shall be approved by the Wilmington Department of Public Works.

1.3 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Storage and Materials
 - 1. Store materials to prevent physical damage.
 - 2. Store pipe and fittings off ground to prevent dirt and debris from entering.
 - 3. Store flexible gasket materials and joint primer or adhesive compounds in cool dry place. Keep rubber gaskets clean, away from oil, grease, excessive heat, and out of direct sunlight.
- B. Handling of Materials
 - 1. Protect materials during transportation and installation to avoid physical damage.
 - 2. Do not install out-of-round pipe.
 - 3. Unload pipe to prevent abrasion.
 - 4. Do not drag or push pipe while handling or distributing on project site.

1.4 SUBMITTALS

- A. Submit manufacturer's product data for all pipe, fittings, gaskets, and appurtenances.
- B. Submit shop drawings for all manholes.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. P.V.C. Pipe and Fittings
 - 1. ASTM D-2241; SDR 26 for diameters up to 15 inches
 - 2. ASTM F-679, PS 115 for diameters larger than 15 inches
 - 3. ASTM 1785, Schedule 40
- B. Ductile Iron Pipe
 - 1. Shall conform to AWWA C-151, and shall be manufactured in eighteen or twenty foot nominal lengths.
 - 2. Use push-on joints, conforming to AWWA C151 and AWWA C11, except for fitting or where mechanical or restrained joints are indicated on the Plans.
- C. All manholes shall be precast Portland cement concrete (p.c.c.) and shall conform with the City of Wilmington Department of Public Works standards and details. Precast manholes shall conform with ASTM C-478 except where noted on the Plans.

PART 3 - EXECUTION

3.1 MATERIAL INSPECTION

- A. The following information shall be clearly marked on each pipe section of P.V.C. pipe:
 - 1. Pipe type and SDR number.
 - 2. Nominal pipe size.
 - 3. The PVC cell classification.
 - 4. Name or trademark of manufacturer.
 - 5. The ASTM Specification designation.
- B. P.V.C. Fittings shall have the following markings:
 - 1. The ASTM Specification designation.
 - 2. Manufacturer's name or trademark.
 - 3. Nominal size.
 - 4. The material designation.
- C. Inspect pipe for defects prior to placement in trench. The pipe and fittings shall be free from visible cracks, holes, foreign inclusions or other injurious defects.
- D. Assure that all materials are of the type specified and are not defective. Unmarked pipe or pipe and materials not meeting Specification requirements shall be removed from the site as directed by the Engineer.

3.2 INSTALLATION

- A. Fine grade trench bottom so that pipe is supported for its full length.

- B. Install piping beginning at the low point of the system, true to grades and alignment indicated on the Plans. Place the bell ends of the pipe facing upstream.
- C. Do not lay pipe on unsuitable material, in wet trench, or in same trench with another pipe or utility.
- D. General Procedure for Joining Pipe
Do not use excavating equipment to force pipe sections together.
 - 1. Hold pipe securely and in proper alignment when joining.
 - 2. Do not disturb previously made joints. Check completed piping to assure joints are intact. Ensure placement of backfill over pipe is accomplished without disturbing pipe position.
 - 3. Do not allow earth, stones, or other debris to enter pipe or fittings.
 - 5. Method of installing joint materials and joining piping shall be in strict accordance with manufacturer's printed instructions.
- E. Sanitary sewer pipe shall be installed in accordance with the requirements of the City of Wilmington Department of Public Works.

3.3 BACKFILL AND COMPACTION

- A. Bedding and Initial Backfill
 - 1. Bedding and initial backfill shall be in accordance with the manufacturer's written instruction, the details on the Plans, or, in absence of said instructions or details, in accordance with Section 31200 of these Specifications.
 - 2. Install initial backfill material as shown on the Plans for the type of pipe being used.
 - 3. When required, material shall be placed under the pipe haunch to provide adequate side support. Material shall be installed for entire trench width and shall be tamped and rodded to insure full contact with pipe at haunch up to the spring line.
 - 4. Little or no tamping of the initial backfill directly over the pipe shall be done.
- B. Final Backfill
 - 1. Final backfill shall be in accordance with Section 312000 of these Specifications.

3.4 TESTING

- A. All testing shall be in accordance with the requirements of the City of Wilmington Department of Public Works and ASTM C828.
- B. Manholes shall be vacuum tested upon request of the City of Wilmington Department of Public Works.
- C. Internal television inspection shall be conducted on all new sewer lines in the presence of the City of Wilmington Department of Public Works. The Department of Public Works must be notified at least 48 hours prior to any testing or inspection. An independent testing firm, approved by the Department of Public Works, shall conduct the test. A copy of all logs, photographs, and tapes shall be submitted to the City of Wilmington Department of Public Works.

3.5 MANHOLES

- A. Manholes shall be installed in accordance with the requirements of the City of Wilmington Department of Public Works
- B. Installation of rubber gaskets for precast manholes shall be in accordance with the manufacturer's recommendations.
- C. Frames shall be well bedded in mortar, making a watertight joint. Cover and frame shall have a shop coat of asphaltic pitch and shall have a field coat of similar paint after the frame is set in final position.
- D. Repair and adjustment of manholes shall be in accordance with the requirements of the City of Wilmington Department of Public Works and Section 602 of the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction.

END OF SECTION

NOT FOR BID

SECTION 33 40 00 - STORMWATER UTILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Furnish and install polyvinyl chloride (PVC) gravity storm sewer pipe and appurtenances as shown on the Plans and described herein.
- B. Furnish and install high density polyethylene (PE) gravity storm sewer pipe and appurtenances as shown on the plans and described herein.
- C. Furnish and install catch basins and manholes, and connect existing pipes to manholes or catch basins, and connect proposed pipes to existing manholes or catch basins as shown on the Plans or as directed by the Engineer.
- D. Repair and adjust catch basins and catch basin tops as shown on the Plans.
- E. Furnish and install underground stormwater management system when indicated on the plans.

1.2 STANDARDS

- A. American Society for Testing and Materials (ASTM)
 1. ASTM D-2241: Polyvinyl Chloride (PVC) Pressure-Rated Pipe.
 2. ASTM 1785: Schedule 40 Polyvinyl Chloride (PVC) Pipe.
 3. ASTM C-76: Reinforced Concrete Culvert Storm Drain and Sewer Pipe
 4. ASTM C-443: Joints for Circular Concrete Sewer and Culvert Pipe
- B. City of Wilmington Department of Public Works Standards and Specifications
- C. Delaware Department of Transportation Standard Specifications for Road and Bridge Construction, dated June 2021, hereinafter referred to as the "Standard Specifications":
 1. Section 601: Pipe Culverts
 2. Section 602: Drainage Structures
 3. Section 1022: Portland Cement Concrete

1.3 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Storage and Materials
 1. Store materials to prevent physical damage.
 2. Store pipe and fittings off the ground to prevent dirt and debris from entering.
 3. Store flexible gasket materials and joint primer or adhesive compounds in cool dry place. Keep rubber gaskets clean, away from oil, grease, excessive heat, and out of direct sunlight.
- B. Handling of Materials
 1. Protect materials during transportation and installation to avoid physical damage.
 2. Do not install out-of-round pipe.

3. Unload pipe to prevent abrasion.
4. Do not drag or push pipe while handling or distributing on project site.

1.4 SUBMITTALS

- A. Submit manufacturer's product data for all pipe, fittings, gaskets, and appurtenances.
- B. Submit shop drawings for all manholes, catch basins, and drainage structures.
- C. Submit manufacturer's data and drawings for underground stormwater management systems, including geotextiles, and base and fill materials.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. P.V.C. Pipe and Fittings
 1. ASTM D-2241; SDR 26.
 2. ASTM 1785, Schedule 40
- B. High Density Polyethylene Pipe and Fittings.
 1. All polyethylene pipe 12-inches or larger in diameter shall have a corrugated outer wall and an integrally formed smooth interior, and shall meet AASHTO M294 and DeDOT Specifications Section 601 for Type "S" high density polyethylene pipe.
 2. Pipes, couplings, and fittings shall meet the requirements of AASHTO M294, modified as follows: Minimum pipe stiffness shall be 35 psi at 5% deflection and 30 psi at 10% deflection, when tested in accordance with ASTM D-2412.
 3. Pipe joints shall be soil-tight or water-tight.
 4. Pipe shall be "N-12" as manufactured by Advanced Drainage Systems, Inc. (ADS), "Sure-Lok", as manufactured by Hancor, or approved equal.
 5. Corrugated polyethylene pipe smaller than 12 inches in diameter shall have a single corrugated wall with annular interior and exterior corrugations. Pipe and fittings shall meet the requirements of AASHTO M252. Pipe joints shall be by cleated bell, split, internal and snap couplers, and shall be soil tight. Pipe shall be as manufactured by Advanced Drainage Systems, Hancor, or approved equal.
- C. All catch basins and manholes shall be precast or cast-in-place Portland cement concrete (p.c.c.) and shall conform to Section 602 of the Standard Specifications. Precast manholes shall conform with ASTM C 478, except as noted on the Plan.
- D. Underground stormwater management systems shall meet the dimensions, specifications, and requirements shown on the Plans. Underground stormwater management systems shall be as manufactured by StormTech, a division of ADS, Inc., or pre-approved equal. Geotextiles and liners shall be as specified by the manufacturer or as shown on the Plans

PART 3 - EXECUTION

3.1 MATERIAL INSPECTION

- A. The following information shall be clearly marked on each pipe section of P.V.C. pipe:

1. Pipe type and SDR number.
 2. Nominal pipe size.
 3. The PVC cell classification.
 4. Name or trademark of manufacturer.
 5. The ASTM Specification designation.
- B. P.V.C. Fittings shall have the following markings:
1. The ASTM Specification designation.
 2. Manufacturer's name or trademark.
 3. Nominal size.
 4. The material designation.
- C. Polyethylene pipe shall be marked with the pipe class, date of manufacture, and the name or trademark of the manufacturer.
- D. The following information shall be clearly marked on each section of reinforced concrete pipe.:
1. The ASTM Specification designation.
 2. Pipe class or strength designation
 3. Date of manufacture.
 4. Name or trademark of manufacturer.
 5. For reinforced pipe with elliptical or quadrant reinforcement, the letter E or Q.
- E. Inspect pipe for defects prior to placement in trench. The pipe and fittings shall be free from visible cracks, holes, foreign inclusions or other injurious defects.
- F. Ensure that all materials are of the type specified and are not defective. Unmarked pipe or pipe and materials not meeting Specification requirements shall be removed from the site as directed by the Engineer.

3.2 INSTALLATION

- A. Fine grade trench bottom so that pipe is supported for its full length.
- B. Install piping beginning at the low point of the system, true to grades and alignment indicated on the Plans. Place the bell ends of the pipe facing upstream.
- C. Do not lay pipe on unsuitable material, in wet trench, or in same trench with another pipe or utility.
- D. General Procedure for Joining Pipe
1. Do not use excavating equipment to force pipe sections together.
 2. Hold pipe securely and in proper alignment when joining.
 3. Do not disturb previously made joints. Check completed piping to assure joints are intact.
 4. Ensure placement of backfill over pipe is accomplished without disturbing pipe position.
 4. Do not allow earth, stones, or other debris to enter pipe or fittings.
 5. Method of installing joint materials and joining piping shall be in strict accordance with manufacturer's printed instructions.

- E. Polyethylene pipe shall be installed in accordance with the manufacturer's written instructions or as directed by the Engineer. Joints for all polyethylene pipe greater than 12-inches in diameter shall be watertight in accordance with ASTM D3212. Gaskets shall meet the requirements of ASTM-F477.

3.3 BACKFILL AND COMPACTION

A. Bedding and Initial Backfill

- 1. Bedding and initial backfill shall be in accordance with the manufacturer's written instructions or, in absence of said instructions, in accordance with Section 31200 of these Specifications.
- 2. Install initial backfill material as shown on the Plan details for the type of pipe being used.
- 3. When required, material shall be placed under the pipe haunch to provide adequate sole support. Material shall be installed for entire trench width and shall be tamped and rodded to insure full contact with pipe at haunch up to the spring line.
- 4. Little or no tamping of the initial backfill directly over the pipe shall be done.

B. Final Backfill

- 1. Final backfill shall be in accordance with Section 31200 of these Specifications.

3.4 CATCH BASINS AND MANHOLES

- A. Catch basins and manholes shall be installed in accordance with Section 602 of the Standard Specifications and in accordance with the requirements of the City of Wilmington Department of Public Works.
- B. Installation of rubber gaskets for precast catch basins and manholes shall be in accordance with the manufacturer's recommendations.
- C. Frames shall be well bedded in mortar making a watertight joint. Cover and frame shall have a shop coat of asphaltic pitch and shall have a field coat of similar paint after the frame is set in final position.
- D. Repair and adjustment of catch basins and manholes shall be in accordance with Section 602 of the Delaware Department of Transportation Standard Specifications for Road and Bridge Construction.

3.6 UNDERGROUND STORMWATER MANAGEMENT SYSTEMS

- A. Underground stormwater management systems shall be installed in strict conformance with the manufacturer's written instructions and the details shown on the Plan. Any variation from the manufacturer's instructions or from the Plans requires prior written authorization.
- B. Geotechnical fabrics and lines shall be installed in accordance with the manufacturer's written instructions. Fabrics shall be laid so as to prevent ripping or tearing. Any ripped, torn, or damaged geotextiles or lines shall be removed and replaced at the Contractor's expense.

END OF SECTION