



SMYRNA SCHOOL DISTRICT
BID No SSD2004-NC_NEWIS

SPECIFICATIONS FOR
SUNNYSIDE INTERMEDIATE
SCHOOL
New School

IN

70 GRACEVILLE DRIVE
SMYRNA, DELAWARE 19977

ARCHITECT'S PROJECT No 22019

Volume 4

PREPARED BY:

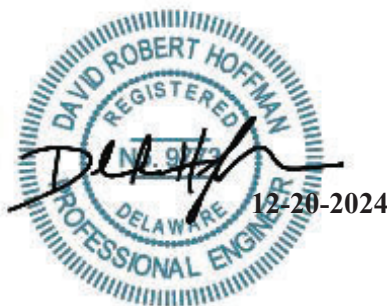
Fearn-Clendaniel Architects, Inc.



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ISSUED FOR BIDDING/CONSTRUCTION

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DIVISION 26 SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL
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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 Division affected by Alternates.

1.3. SUMMARY

- A. Section Includes:
 - 1. Common electrical installation requirements.
 - 2. Electrical equipment coordination and installation.
 - 3. Sleeves for raceways and cables.
 - 4. Sleeve seals.
 - 5. Foam duct sealant.
 - 6. Grout.
 - 7. Plywood backboards.
 - 8. Protective wire guards.
 - 9. Spare key cabinet(s).
- 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.
- E. 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.
- F. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.
- G. Coordinate the work under Division 26 with the work of all other construction trades.
- H. 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.

1.4. CONTRACTOR QUALIFICATION

- A. Any Contractor or Subcontractor performing work under Division 26 shall be fully qualified and acceptable to the Architect/Engineer and Owner. Submit the following evidence when requested:
 - 1. A list of not less than five comparable projects which the Contractor completed.
 - 2. Letter of reference from not less than three registered professional engineers, general contractors or building owners.
 - 3. Local and/or State License, where required.
 - 4. Membership in trade or professional organizations where required.
 - 5. Copy of Master Electrician's License.
- B. A Contractor is any individual, partnership, or corporation, performing work by contract or subcontract on this project.
- C. Acceptance of a Contractor or Subcontractor will not relieve the Contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work, of various trades.
- D. Supervisory Qualifications: The electrical work on the project shall be under the direct supervision of a licensed Master Electrician.
- E. Qualifications of Installers:
 - 1. For the actual fabrication, installation, and testing of the work, shall use only thoroughly trained and experienced personnel who are completely familiar with the requirements of this work and with the installation recommendations of the manufacturers of the specified items.
 - 2. Utilize a full-time project foreman in charge of all electrical work. This person shall be fully qualified and experience in such work and shall be available, on site, at all times during Construction. All problems, questions, coordination, etc. related to electrical work shall take place through this person to the Architect.

1.5. PERMITS, FEES, AND INSPECTIONS

- 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, 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.

- F. State Mandated Electrical Inspections: The Contractor shall obtain electrical installation inspection from a non-governmental electrical inspector approved by the State Fire Marshal. The Contractor shall coordinate inspections, coordinate inspection schedule with the Owner, and obtain the electrical inspection certificate within 15 days after completion of electrical installation. The Contractor shall obtain electrical inspections of portions of the Work as they are completed and as required by the electrical inspector, and sufficiently ahead of close-in work so that corrections and re-inspections may be made, and in all cases while the area is accessible and visible for inspection.

1.6. UTILITY COMPANY COORDINATION

- A. The Engineer has made the initial service application to the utility company for the purposes of obtaining a new electric service. The utility company's contact person is identified in Division 26 Section 261120, "Utility Incoming Service Provisions". After award of the contract notice to proceed, the Contractor is responsible for all communication, scheduling, site meetings, and follow-up with the utility company necessary for the installation of said utility in a timely manner, so service is active and available when needed for start-up, testing, and operation of all equipment and systems prior to substantial completion. Utility fees are to be paid directly by the Owner.
- B. 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.
- C. The Owner shall make the application for electrical service and pay for all service charges, as coordinated with the Contractor.

1.7. 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.

1.8. 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 overhead ducts, piping, etc. Where any doubt exists, the exact location shall be determined by the Owner.
- C. No electrical equipment, e.g. switchboards, transformers, panelboards, disconnect switches, motor controllers, etc. shall be installed beneath ductwork, piping, etc.
- D. All general trades and existing conditions shall be checked before installing any outlets, power wiring, etc.
- E. 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.
- F. 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.
- G. 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” 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.
- H. Work not specifically outlined, but reasonably incidental to the completion of the work, shall be included without additional compensation from the Architect, Engineer, and Owner.
- I. 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.
- J. The complete set of Architectural, Civil, Structural, Food Service, Technology, Mechanical, and Electrical Drawings and Specifications apply to this work. The successful Bidder shall familiarize himself with all other related documents.

1.9. 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.
- B. 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. 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.

1.10. ELECTRICAL WORK UNDER OTHER DIVISIONS

A. Architectural Equipment and Systems

- 1. In general, any electrically operated or controlled equipment furnished under Architectural divisions shall be supplied with control wiring, transformers, contacts, etc.
- 2. Division 26 shall provide power circuits to such equipment and a disconnecting means for each piece of equipment, as well as all electrical control equipment and wiring related thereto.
- 3. Architectural Equipment refers to, but is not limited to the following:
 - a. Appliances
 - i. Includes, but is not limited to refrigerators, microwaves, dishwashers, ranges, range hoods, clothes washers, clothes dryers, whirlpools, etc.
 - ii. Verify equipment nameplates and connection requirements prior to rough-in.
 - iii. Coordinate mounting heights and locations of outlet boxes serving appliances with approved appliance product data and approved casework shop drawings where applicable.
 - b. Cabinets, Casework and Countertops
 - i. Do not install outlets, switches, etc. behind casework, cabinets, etc.
 - ii. Receptacle outlets and data/telephone outlets shall be mounted above the countertops unless otherwise indicated.
 - iii. Where outlets are installed below countertops, provide grommets through countertops for cabling. Coordinate drilling of casework/countertops with casework installer.
 - iv. Coordinate outlets above and below countertops with approved casework shop drawings to avoid conflicts with sinks and other appurtenances.
 - c. Classroom Equipment
 - i. Includes, but is not limited to television mounting brackets, exhaust/fume hoods, goggle cabinets, outlets in lab benches, etc.
 - ii. Verify equipment nameplates and connection requirements prior

- to rough-in.
 - iii. Coordinate mounting heights and locations of outlet boxes serving equipment with approved product data and approved casework shop drawings where applicable.
- d. Conveyance Systems
 - i. Includes, but is not limited to elevators, etc.
- e. Display Cases
 - i. Provide power circuit to display case lighting fixture(s) furnished with display cases under Architectural division. Coordinate voltage with equipment supplier/installer.
 - ii. Coordinate installation of lighting fixture(s) furnished under Division 26 with display case supplier/installer.
- f. Door Hardware
 - i. Includes, but is not limited to electric strikes, magnetic hold-open devices, power-assist door operators, raise/lower switches, etc.
 - ii. Verify voltages of door hardware with approved door hardware shop drawings.
 - iii. Coordinate mounting height and location of power-assist door operator paddle stations with Architect to ensure ADA compliance.
 - iv. Coordinate mounting height and location of raise/lower switches for overhead coiling doors/grilles with Architect.
- g. Electric Hand Dryers
 - i. Verify voltage and overcurrent protection requirements with approved shop drawings.
 - ii. Coordinate mounting heights and locations of electric hand dryers with Architect.
- h. Glazing Systems
 - i. Includes but is not limited to commercial storefront, curtain walls, skylights, windows, etc.
 - ii. Coordinate installation of exit signs above doors that are integral to glazing systems. Conceal power wiring (MC cable) within glazing systems.
- i. Gymnasium Equipment
 - i. Includes, but is not limited to electrically-operated bleachers, basketball backstops, scoreboards, shot timers, divider curtains, etc.
 - ii. Verify voltage, overcurrent protection, and control requirements with approved shop drawings.
 - iii. Coordinate receptacle configurations for all equipment furnished with cord-and-plug assemblies.
 - iv. Coordinate mounting heights and locations of control devices furnished with equipment, e.g. raise/lower switches, with Architect.
- j. Signage
 - i. Includes but is not limited to building signage, monument signage, site signage, etc.
- k. Stage Equipment
 - i. Includes but is not limited to curtains, rigging, projectors, projection screens, etc.

- ii. Coordinate mounting heights and locations of control devices furnished with equipment, e.g. raise/lower switches, with Architect.
- l. Window Shades
 - i. Verify voltage, overcurrent protection, and control requirements with equipment supplier/installer.
 - ii. Coordinate mounting heights and locations of raise/lower switches with Architect.
 - iii. Verify quantity and type of shade motors with equipment supplier/installer.

B. Civil Equipment and Systems

- 1. In general, any electrically operated or controlled equipment furnished under Civil divisions shall be supplied with control wiring, transformers, contacts, etc.
- 2. Division 26 shall provide power circuits to such equipment and a disconnecting means for each piece of equipment, as well as all electrical control equipment and wiring related thereto.
- 3. Civil Equipment refers to, but is not limited to the following:
 - a. Site Signage
 - b. Site Lighting

C. Food Service (Kitchen) Equipment and Systems

- 1. In general, any electrically operated or controlled equipment furnished under Food Service divisions shall be supplied with control wiring, transformers, contacts, etc.
- 2. Division 26 shall provide power circuits to such equipment and a disconnecting means for each piece of equipment, as well as all electrical control equipment and wiring related thereto.
- 3. Food Service Equipment refers to, but is not limited to the following:
 - a. Commercial Kitchen Appliances
 - i. Includes, but is not limited to refrigerators, freezers, warming cabinets, vending machines, cash registers, microwaves, dishwashers, garbage disposals, ranges, mixers, kettles, convection ovens, utility distribution systems, etc.
 - ii. Verify equipment nameplates and connection requirements prior to rough-in.
 - iii. Coordinate mounting heights and locations of outlet boxes serving appliances with approved appliance product data and approved casework shop drawings where applicable.
 - b. Kitchen Fire Suppression Systems
 - i. Connection(s) between kitchen fire suppression system(s) and fire alarm system shall be provided by Owner's vendor.
 - ii. Provide connection(s) between kitchen fire suppression system(s) and shunt-trip mechanisms on circuit breakers serving equipment located beneath kitchen ventilation hoods such that upon activation of fire suppression system, shunt-trip mechanisms energize and open circuit breakers, de-energizing equipment located beneath ventilation hoods.

- c. Kitchen Ventilation Hoods
 - i. Provide shunt-trip mechanisms for circuit breakers serving kitchen equipment located beneath kitchen ventilation hoods. Connect shunt-trip mechanisms to kitchen fire suppression system as described above.

D. HVAC Equipment and Systems

1. In general, any electrically operated or controlled equipment furnished under HVAC divisions shall be supplied with control wiring, transformers, contacts, etc.
2. Division 26 shall provide power circuits to such equipment and a disconnecting means for each piece of equipment, as well as all electrical control equipment and wiring related thereto.
3. Certain mechanical units are furnished from the factory with motor starters, contactors, transformers, fuses, wiring, etc., required for fans, pumps, etc. When this equipment is supplied from the factory, Division 26 shall coordinate with Division 23 such that only one set of starters, fuses, switches, etc. is provided.
4. Some HVAC equipment must be protected by fuses, which shall be marked on the equipment nameplate. In these instances, if the equipment has an integral non-fused disconnecting means, the fusible safety switch indicated on the electrical drawings must remain per NEC Article 440.
5. In general, control and interlock equipment (including, but not limited to wiring, conduit, transformers, relays, contacts, etc.) for HVAC equipment and systems is furnished under Division 23. Division 26 shall install and connect all equipment as necessary.
6. HVAC equipment refers to, but is not limited to the following:
 - a. Air Handling Units
 - b. ATC Panels
 - c. Ductless Split Systems
 - d. Ductwork
 - i. Do not install any electrical equipment, including but not limited to switchboards, transformers, panelboards, safety switches, motor controllers, etc. beneath ductwork. Where this cannot be accomplished due to field conditions, notify the Architect in writing.
 - e. Electric Unit Heaters
 - f. Energy Recovery Ventilators
 - g. Exhaust Fans
 - h. Ground Loop Pumps
 - i. Heat Pumps
 - j. Make-up Air Units
 - k. Outside Air Units
 - l. Piping
 - i. Do not install any electrical equipment, including but not limited to switchboards, transformers, panelboards, safety switches, motor controllers, etc. beneath piping. Where this cannot be accomplished due to field conditions, notify the Architect/Engineer in writing.
 - m. Radiant Heat Panels
 - n. Ventilation Fans

7. To ensure proper electrical coordination between the electrical components supplied under Division 26 and the equipment supplied under Division 23, a schedule shall be submitted, prior to start of work, for review by the Engineer with the following column headings:

- a. Equipment or Item
- b. HP or KVA
- c. Voltage and Phase
- d. Power Factor
- e. Capacitor
- f. Motor Starter
- g. Disconnect
- h. Controls
- i. Remarks

E. Owner Furnished Equipment and Systems

1. In general, any electrically operated or controlled equipment furnished by the Owner shall be supplied with control wiring, transformers, contacts, etc.
2. Division 26 shall provide power circuits to such equipment and a disconnecting means for each piece of equipment, as well as all electrical control equipment and wiring related thereto.
3. Owner equipment refers to, but is not limited to the following:
 - a. Existing Appliances and/or Equipment
 - b. Electronic Appliances
 - i. Includes, but is not limited to televisions, computers, copy/fax machines, printers, etc.
 - ii. Verify equipment nameplates and connection requirements prior to rough-in.
 - iii. Coordinate mounting heights and locations of outlet boxes serving appliances with approved appliance product data and approved casework shop drawings where applicable.
 - c. Kitchen/Laundry Appliances
 - i. Includes, but is not limited to refrigerators, microwaves, dishwashers, ranges, range hoods, clothes washers, clothes dryers, whirlpools, etc.
 - ii. Verify equipment nameplates and connection requirements prior to rough-in.
 - iii. Coordinate mounting heights and locations of outlet boxes serving appliances with approved appliance product data and approved casework shop drawings where applicable.

F. Plumbing Equipment and Systems

1. In general, any electrically operated or controlled equipment furnished under Plumbing divisions shall be supplied with control wiring, transformers, contacts, etc.
2. Division 26 shall provide power circuits to such equipment and a disconnecting means for each piece of equipment, as well as all electrical control equipment and wiring related thereto.

3. Certain plumbing units are furnished from the factory with motor starters, contactors, transformers, fuses, wiring, etc., required for pumps, etc. When this equipment is supplied from the factory, Division 26 shall coordinate with Division 22 such that only one set of starters, fuses, switches, etc. is provided.
4. In general, control and interlock equipment (including, but not limited to wiring, conduit, transformers, relays, contacts, etc.) for plumbing equipment and systems is furnished under Division 22. Division 26 shall install and connect all equipment as necessary.
5. Plumbing equipment refers to, but is not limited to the following:
 - a. Electric Water Coolers
 - i. Coordinate mounting height and location of receptacle outlets serving electric water coolers with approved shop drawings.
 - b. Floor Drains
 - i. Coordinate routing of conduits and raceways in floor slabs with floor drains.
 - c. Condensate Pumps
 - i. Coordinate connection type (i.e. switch or cord-and-plug) with approved shop drawings.
 - d. Gas-Fired Water Heaters
 - i. Coordinate connection type (i.e. switch or cord-and-plug) with approved shop drawings.
 - e. Ice Makers
 - f. Piping
 - i. Do not install any electrical equipment, including but not limited to switchboards, transformers, panelboards, safety switches, motor controllers, etc. beneath piping. Where this cannot be accomplished due to field conditions, notify the Architect in writing.
 - g. Recirculation Pumps
 - h. Sinks
 - i. Sump Pumps
 - i. Coordinate sump pump control panel connection type (i.e. switch or cord-and-plug) with approved shop drawings.
 - ii. Provide 2-inch conduit with pull string from control panel to sump pump for control and power cabling provided with equipment.
 - j. Trap Priming Stations

1.11. 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.

1.12. 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.

1.13. SUBMITTALS

- A. Product Data: Include complete descriptive product data for items specified in Part 2 of this Section.

1.14. SUBMITTAL PROCEDURES

- A. Refer to Division 01 Section, "Submittal Procedures", for requirements in addition to those indicated herein.
- B. 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 and/or Engineer to be in the best interest of the Owner.
- C. 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 as outlined below.
- D. Electronic submittals shall be prepared as a Portable Document Format (PDF) file and shall include as page 1 the Contractor's stamp, followed by the submittal contents. Submittal form shall identify the Project, Contractor, Subcontractor or Supplier, and pertinent Contract Document references.
- E. Submittals shall consist of specifications, product data sheets, manufacturer's catalog cuts, dimensional shop drawings, wiring diagrams, installation instructions, samples, and any

other information necessary to indicate complete compliance with Contract Documents.

- F. 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.
- G. Identify submittals, indicating intended application, location and service of submitted items. Refer to Specification sections or paragraphs and Drawings where applicable.
- H. Clearly indicate exact type, model number, style, size, operating characteristics, ratings, options and special features of proposed item specifically for application to this project. Submittals of a general nature will not be acceptable.
- I. 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.
- J. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and all electrical requirements for equipment submitted. The Contractor shall be responsible for correctness of all submittals.
- K. 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.
- L. 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.
- M. 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.
- N. Where proposals to use an item of equipment or application other than that specified or detailed on the Contract Drawings, which requires any redesign of the structure, partitions, foundation, HVAC, piping, wiring, or any other part of the mechanical, electrical, or architectural layout, all such redesign and all new drawings and detailing required thereafter shall be prepared by the Contractor at his own expense for review by the Owner's representative before any such work is implemented.
- O. All Contractor-proposed changes and revisions shall be at the Contractor's risk and expense. The Contractor shall fully coordinate all revisions, substitutions and changes with other trades for a complete, code compliant, and fully functional installation.
- P. 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.

Q. Every submittal including, but not limited to the list below, shall be forwarded with its own transmittal as a separate, distinct submittal. Identify all submittals by the name of the item/system and the applicable Specification Section and/or Drawing number. Grouping of items/systems that are not related shall be unacceptable.

R. Items and Systems

1. Access Doors
2. Arc Flash Hazard Analysis and Labels
3. Battery Packs for Lighting Fixtures
4. Circuit Breakers
5. Commercial Pedestals
6. Conductors and Cables - 600V or Less
7. Conduit and Raceway
8. Connectors and Splices
9. Disconnect (Safety) Switches
10. Electric Heating Cables and Controls
11. Electrical Connection Coordination Schedule
12. Electricity Meters
13. Elevator Control Switches
14. Emergency Off Push-Buttons
15. Enclosed Circuit Breakers
16. Enclosed Contactors
17. Equipment Nameplates/Labels
18. Firestopping Materials
19. Foam Duct Sealant
20. Fuses, 600V or Less
21. Generator
22. Ground Busbars
23. Ground Conductors
24. Ground Rods
25. Grout
26. Handholes
27. Hangers and Supports
28. Identification Products
29. Installation/Coordination Drawings
30. Installer Certificates
31. Junction and Pull Boxes, Custom Sizes
32. Junction and Pull Boxes, Standard Sizes
33. Lamps
34. Lighting Control System
35. Lighting Fixtures, Exterior
36. Lighting Fixtures, Interior
37. Lighting, Theatrical
38. Lightning Protection System
39. Manholes and Manhole Accessories
40. Medium Voltage Cable Termination & Splice Kits
41. Medium Voltage Cables
42. Medium Voltage Grounding
43. Motor Controllers
44. Operation and Maintenance Manual

45. Outlet and Device Boxes
 46. Panelboard Circuit Directories
 47. Panelboards
 48. Power System Studies
 49. Qualification Data
 50. Receptacles
 51. Record Drawings
 52. Retractable Cord Reels
 53. Roof Penetration Boots /Curbs
 54. Sleeves
 55. Surge Protective Devices
 56. Switchboards
 57. Testing Agency Qualifications
 58. Test Reports
 59. Toggle/Snap Switches
 60. Transfer Switches
 61. Transformers, 600V and Less
 62. Transformers, Medium Voltage
 63. Underground Ductbank Products
 64. Weatherproof Boxes and Covers
 65. Wiring Diagrams
- S. Submit for approval any other submittals as required by the Architect, Engineer, or Owner. 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.
- T. 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.
- U. For resubmissions, the Contractor must address in writing all of the Engineer's comments on the original submission to verify compliance.

1.15. 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. Shop drawings shall include identification of products being installed, compliance with specified standards, notation of coordination requirements, notation of dimensions verified by field measurement, etc. Do not base shop drawings on reproductions of the Contract Documents or standard printed data.
- C. Submit shop drawings concurrent with product data. Shop drawings received without associated product data will be returned without review.
- D. Submit for approval schematic diagrams of each electrical system installed in the building, including but not limited to Riser Diagrams and Schematic Wiring Diagrams for the following systems:

1. Emergency Power Supply System – Generator and Transfer Switch(es)
 2. Lighting Control System
 3. Lightning Protection System
 4. Occupancy Sensor Layout
 5. Stage/Platform Lighting and Dimming System
- E. Shop Drawing 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 inserted into the O&M Manual specified herein.
- F. Submit for approval any other shop drawings as required by the Architect, Engineer, or Owner. 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.
- G. 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.
- H. Refer to individual Specification Sections and Contract Drawings for additional shop drawing requirements.
- I. For resubmissions, the Contractor must address in writing all of the Engineer's comments on the original submission to verify compliance.

1.16. DEFINITIONS

- A. Approve: To permit use of material, 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, **or** 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.

1.17. 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.

1.18. OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall prepare six (6) hard copies and electronic copies of the Operation and Maintenance Manual and shall deliver these copies of the manual to the Owner. Provide one (1) electronic copy for each hard copy set of the O&M manual.
- B. The manual shall be as specified herein. The manual must be approved and will not be

accepted as final until so stamped.

- C. Hard copies of the manual shall be bound in three-ring loose-leaf binders similar to National No. 3881 with the following title lettered on the front and spine of the binder: *Operation and Maintenance Manual – Smyrna School District – New Sunnyside Intermediate School – Electrical*.
 - 1. Provide divider tabs and table of contents for organizing and separating information. Tab titling shall be clearly printed under reinforced plastic tabs.
 - 2. If more than one (1) binder is required, volume numbers shall be included on front and spine of each volume.
 - 3. 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 a pull-out.
- D. Electronic copies of the manual shall be saved on USB flash drives, and shall be in searchable PDF format with interactive index tabs. Approved electronic copies shall be stored in flash drive zipper cases in front of volume 1 (if applicable) of hard copies of the manual.
- E. 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. Directory listing names, addresses, e-mail addresses, and telephone numbers for Architect, Engineer, Construction Manager, Contractor, Sub-contractor(s), equipment suppliers, sales and authorized service representatives.
 - 3. Maintenance operation and lubrication instructions on each piece of equipment furnished.
 - 4. Complete catalog data on each piece of electrical equipment furnished including approved Shop Drawing/Submittal with Engineer's Comments (if any).
 - 5. Manufacturer's extended limited warranties on equipment.
 - 6. Catalog data of all equipment, starters, etc. shall include wiring diagrams, parts list and assembly drawing(s).
 - 7. Access panel charts with index illustrating the location and purpose of access panels.
 - 8. Approved Electrical Certificates, including certificate of approval from electrical inspector.
 - 9. List of extra materials turned over to Owner, with transmittal/receipt signed by Owner.
 - 10. Sign-in sheets from demonstration and training sessions.
 - 11. Start-up and test reports for equipment.
- F. Additional items identified within other Sections of these Specifications.
- G. Submit Operation and Maintenance Manual prior to the anticipated date of Substantial Completion for Engineer review and approval. Substantial Completion requires that Operation and Maintenance Manuals be reviewed and approved.

1.19. 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.
- C. Contractor shall note respective addendum, supplemental instruction, request for information, change order, etc. number adjacent to all red-line changes on Record Drawings.

1.20. INSTRUCTION

- A. Upon completion of all work, thoroughly instruct the Owner's representatives in the proper operation and maintenance of all electrical equipment and systems.
- B. Instructions shall be done only after completed systems have been put into operation and tested for proper operation and performance.
- C. 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.
- D. Furnish the necessary technicians, skilled workers, and helpers to operate the electrical systems and equipment of the entire project for one (1) 8-hour day.
- E. Where specified in technical sections, provide longer periods required for specialized equipment.
- F. The Operation and Maintenance Manual shall be available at the time of the instructions, for use by Instructors and Owner personnel.
- G. Deliver all instruction materials to the Owner prior to the formal instruction period.
- H. Schedule the general and specialized instruction periods for a time agreed upon by the Owner and Engineer.
- I. Cleanup: Collect used and leftover educational materials and remove from Project site. Remove instructional equipment. Restore systems and equipment to condition existing before initial training use.

1.21. DEMONSTRATION AND TRAINING VIDEO RECORDINGS

- A. General: Record demonstration and training video recordings. Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids, but not student practice.
 - 1. At beginning of each training module, record each chart containing learning objective and lesson outline.
- B. Video Recording Format: Provide high-quality color video recordings with menu navigation in format acceptable to Owner.

- C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.
- D. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.
- E. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.
- F. Pre-Produced Video Recordings: Provide video recordings used as a component of training modules in same format as recordings of live training.

1.22. 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 ¼ 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 areas 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. Pad-mounted equipment and equipment connections.
 - 2. Underground conduits and ductbanks.
 - 3. 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 raceways described in notes or indicated by home run symbols.
5. The complete set of Architectural, Civil, Structural, Food Service, Technology, Mechanical, and Electrical Drawings and Specifications apply to this work. The successful bidder shall familiarize himself with all other related documents to avoid possible 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. GROUT

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

2.3. 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. Basis 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).

2.4. BACKBOARDS

- A. Backboards: Plywood, A/C grade, fire-retardant treated, 3/4" x 48" x 96" (19 x 1220 x 2440 mm) with no added urea formaldehyde.
- B. Install each fire-retardant-treated plywood backboard six inches off the floor to bottom. Secure backboards with a minimum of eight (8) screws. Plywood backboards shall have one side with exterior glue and one finished smooth side. Mark all backboards and cabinets with appropriate legends (e.g., "COMM").
- C. Verify with local codes or AHJ prior to painting fire-retardant-treated plywood backboard with stamped fire rating labels. If allowed by code, paint fire-retardant-treated plywood backboard with coats of durable white enamel (or other finish color as selected by the Architect).

2.5. PROTECTIVE WIRE GUARDS/SHIELDS

- A. Provide protective guards over devices subject to physical damage. All devices installed in the gymnasium, 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 Fixtures
 2. Clocks
 3. Bells
 4. Fire Alarm Pull Stations
 5. Thermostats
 6. Smoke/Heat Detectors
 7. Speakers
 8. Fire Alarm Audio/Visual Devices (Horns, Strobes, etc...)
 9. Exit Signs
 10. Emergency Lighting Units
 11. Security Devices/Motion Detectors
 12. Wiring Devices
 13. Emergency Shut-Off Stations
 14. Other Devices as required by Owner
- C. Wireguards shall be fabricated from ¼-inch (9-gauge) cold-rolled steel rods, welded together with mounting tabs. Wireguards 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. Indoor Protective Shield: Factory-fabricated, clear thermoplastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
- E. Protective guards/shields 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.

2.6. SPARE KEY CABINET

- A. Description: Wall-mounted, locking utility cabinet(s) with key hooks for spare keys provided with electrical equipment.
- B. Construction: 16 or 14 gauge steel, ANSI 61 gray polyester powder paint finish inside and out.
- C. Features:
1. Four mounting keyholes in back of enclosure
 2. Removable door with reversible hinge; door can hinge from either left or right side and can be changed without tools
 3. Door has quarter-turn key lock; two keys included
 4. Retractable spring hinge
 5. Integral key hooks in door and back of enclosure
- D. Dimensions: Cabinet(s) shall be of proper size for orderly storage of spare keys stored in the same, plus space for 15 percent spare capacity. Cabinet(s) shall be no smaller than 12”H x 12”W x 2”D.

- E. Identification: Provide engraved nameplate to read “SPARE KEYS” in 1/2" high lettering on front door of cabinet(s). Refer to Division 26 Section, “Electrical Identification” for nameplate requirements.
- F. Installation: Provide one (1) locking key cabinet in the main electrical room. Cabinet(s) shall be mounted 5’-6” to top unless otherwise noted on the Contract Drawings.
- G. Basis of Design: Provide key hook style locking utility cabinet as manufactured by Hoffman/Pentair, 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, including step-down or step-up dry-type transformers as required. Exact requirements for temporary service shall be determined by the Construction Manager and the successful bidder.
- C. Provide all underground and/or overhead equipment, transformers, overcurrent devices, wires, connections, etc., for obtaining power from utility company lines.
- D. 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.
- E. 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. Six (6) 20-ampere circuits 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. Power for crane operation if required.
- F. 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

- G. The Owner shall pay for utility costs for temporary service for construction power.
- H. The Owner shall pay for all energy charges for temporary service.
- I. Remove all temporary power installations and connections after permanent power is established and/or prior to completion of the project.

3.2. OUTAGES

- A. While work is in progress, except for designated short intervals during which connections are made, continuity of service shall be maintained to all 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 systems caused by his operations.
- B. 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.
- C. Submit Outage Request Form, attached at the end of this Section, to Owner for approval.

3.3. 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:
 - 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 sheeting and/or shoring as required for protection of work and safety of personnel. Follow local, State, OSHA, and other applicable Guidelines.
 - 3. Keep excavations dry. Protect excavations from freezing.
- C. Backfilling:
 - 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.

3.4. 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 NEC Article 110.
- 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 requirements for each piece of equipment receiving one or more electrical connections, including but not limited to voltage, phase, and maximum fuse/overcurrent protection device rating. Provide electrical circuit of proper characteristics to serve provided equipment.
- 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. Make all connections to equipment in accordance with manufacturer's instructions.
- J. Right of Way: Give to piping systems installed at a required slope.
- K. Coordinate electrical work under other Divisions in accordance with Part 1 of this Section, Article "Electrical Work Under Other Divisions".
- L. Maintain building egress and traffic ways at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and Authorities Having Jurisdiction (AHJ).

3.5. 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 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.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 26 Section 260528, "Firestopping for Electrical Systems".

3.6. 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 skilled in the particular trades required.
- B. Do not cut structural members without approval from the Architect or Structural Engineer.

3.7. CONCRETE AND MASONRY WORK

- A. Furnish and install concrete and masonry work for equipment foundations, supports, pads, and other items required under Division 26.
- B. Perform work in accordance with requirements of Division 03 and other applicable Divisions of these Specifications.
- C. Concrete shall achieve compressive strength not less than 3,000 psi after 28 days unless otherwise indicated on the Contract Drawings or manufacturer's shop drawings.
- D. Grout shall be non-shrink, high strength mortar, free of iron of 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.
- E. 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 main reinforcing shall be as follows:
 - 1. Slabs - 3/4 inch
 - 2. Concrete poured against earth - 3 inches
 - 3. Other locations - 2 inches
- F. Properly align, level, and grout all equipment where necessary.

3.8. HANGERS AND SUPPORTS

- 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 interior pad-mounted equipment, extending a minimum of 6 inches beyond equipment bases, unless otherwise noted.
 - 2. Provide six (6) inch high concrete foundations (housekeeping pads) for all exterior pad-mounted equipment, extending a minimum of 12 inches beyond equipment bases, unless otherwise noted.
 - 3. 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.
 - 4. Unless otherwise specified, provide all concrete work required in accordance with the requirements of Division 03.
 - 5. 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.
 - 6. Determine exact location of all equipment, foundations, and supports after Shop Drawings of equipment have been approved.
- D. Refer to Division 26 Section 260529, “Hangers and Supports for Electrical Systems”, for additional requirements.

3.9. WALL AND FLOOR PENETRATIONS

- A. All penetrations of partitions, ceilings, roofs and floors under Division 26 shall be sleeved, sealed, and caulked as specified herein.
- 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 07 Section, “Penetration Firestopping” and Division 26 Section 260528, “Firestopping for Electrical Systems”.
- C. Where penetrating through exterior walls below grade, provide waterproof sleeve seals, as specified in Part 2 of this Section.
- D. 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.

3.10. PENETRATION OF WATERPROOF CONSTRUCTION

- A. The building shall remain watertight at all times.
- B. 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 all necessary curbs, flashings, fittings, sleeves, and caulking to make penetrations absolutely watertight.
- C. Where conduits penetrate roofs, flash pipe with Stoneman Stormtite, Pate or approved equal, roof flashing assemblies with skirt and caulked counter flashing sleeve.
- D. Furnish and install pitch pockets or weather tight curb assemblies where required.
- E. Furnish and install curbs 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.

3.11. 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. Sleeves installed in floors shall extend 2 inches (50 mm) above finished floor level unless otherwise indicated on the Contract Drawings.
- 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
- I. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- J. 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, "Joint Sealants".

- K. 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 07 Section, "Penetration Firestopping" and Division 26 Section 260258, "Firestopping for Electrical Systems".
- L. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- M. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and joint sealant/grout.
- N. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals. Seal interior of each raceway with Foam Duct Sealant as specified herein.

3.12. 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 260528, "Firestopping for Electrical Systems".

3.13. 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 lift-out 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 in accordance with OSHA 29 CFR 1910 Subpart D and 1910.303(g).

3.14. 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, conduit, boxes, 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, boxes, equipment, etc. shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.
- I. Do not paint panelboard fronts, switchboards, transformers, motor controllers, safety switches, grounding busbars, equipment nameplates, warning labels, etc.

3.15. COLOR SELECTION

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

3.16. 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.

3.17. 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 or during construction, unless approved by Owner in writing. Refer to Division 01 Section "Temporary Facilities and Controls".
- E. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items.

3.18. 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.

3.19. TESTING AND ADJUSTMENT

- A. Perform all tests which are specified or required to demonstrate that the work is installed and operating properly. Where 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 for approval.

END OF SECTION

OUTAGE REQUEST FORM

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)

PART 1 (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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DIVISION 26 SECTION 26 05 10
ELEVATOR EQUIPMENT WIRING AND PROVISIONS
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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.
- B. Related Sections include the following:
 - 1. Division 26 Section 260500, “Common Work Results for Electrical”, for basic electrical installation requirements.
 - 2. Division 26 Section 262726, “Wiring Devices”, for NEMA 4 receptacle outlets in elevator pits and light switches serving elevator pit/shaft lighting fixtures.
 - 3. Division 26 Section 262816, “Enclosed Switches and Circuit Breakers”, for safety switches serving elevator cab lighting and enclosed circuit breakers serving as the disconnecting means for the elevator controller.
 - 4. Division 26 Section 265100, “Interior Lighting”, for general requirements for lighting fixtures installed in elevator pits/shafts.

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. Elevator pit sump pump.
 - 2. Elevator disconnecting means shunt trip connections.
 - 3. Light(s) and receptacle(s) in elevator pit/shaft.
 - 4. Elevator shunt trip control circuit monitoring on the fire alarm system shall be provided by the Owner’s fire alarm vendor.
 - 5. Elevator lobby smoke detector connections shall be provided by the Owner’s fire alarm vendor.
- 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 lighting fixtures, 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. 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. Disconnect Switches
 - a. Refer to Division 26 Section 262816, “Enclosed Switches and Circuit Breakers”.
 - 2. Enclosed Circuit Breakers
 - a. Refer to Division 26 Section 262816, “Enclosed Switches and Circuit Breakers”.

PART 3. EXECUTION

3.1. GENERAL INSTALLATION REQUIREMENTS

- 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.
- B. Ensure that no electrical conduits, raceways, etc. are routed over elevator shaft.
- C. Work performed under Division 26 shall not create openings in elevator shaft walls or ceilings, unless specifically serving items in elevator shaft pit. All penetrations shall be sealed with firestopping materials to maintain fire rating of elevator shaft.

3.2. ELECTRICAL PROVISIONS

- A. Provide lockable, heavy duty type, fused disconnect switches and/or enclosed circuit

breakers to serve circuits serving elevator cab power (lighting/ventilation), for elevator drive, 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. Disconnect switches shall be lockable in the “open” position and the “closed” position. Provide each disconnect with an equipment nameplate to identify the location of the supply side overcurrent protection device.

- B. Install disconnect switches and/or enclosed circuit breakers adjacent to elevator equipment room door. Locate on strike side of door. Provide one disconnecting means for each elevator controller unit.
- C. Provide all power wiring from source through disconnecting means to elevator controller to motor.
- D. Provide 1-inch conduit, with pull string from each elevator controller to the nearest telecommunications closet.
- E. Provide lock-clip devices on each circuit breaker serving elevator car and room, both lighting and power circuits.
- F. Provide shunt trip device serving each elevator controller. Connect to heat detectors as required. Provide power to shunt trip unit as required. Size per elevator supplier directions.
- G. Provide all wiring for and mount exterior alarm bell. Feed from emergency source.
- H. Provide NEMA 4 rated lighting fixtures and duplex GFCI receptacle in NEMA 4 enclosure in elevator pit. Provide light switch with weatherproof cover adjacent to access ladder near the hoistway door, 36-inch above door sill. Provide light switch, GFCI receptacle and lighting fixtures on every other floor above the lowest level for each elevator. Provide in accordance with NEC Articles 620-24 and 620-85.
- I. All traveling cables, control stations, control station wiring and final control connections at the controller shall be furnished and installed under Division 14.
- J. 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.
- K. Provide for each elevator car, a separate dedicated 120 volt, 20 ampere branch circuit with a lockable fused, disconnect switch in the elevator machine room, with two (2) 12 AWG and one (1) 12 AWG ground in ¾-inch conduit, to each elevator controller, to serve car lighting, ventilation and car top receptacle.

3.3. FIRE ALARM PROVISIONS

- A. Provide smoke detector in each elevator equipment room or space. Connect main alarm contacts to fire alarm system and auxiliary contacts to the controller per BOCA 2611.4 and ANSI/ASME A17.A. Provide remote indicating lamp unit at door.
- B. Provide heat detectors within 24-inches of each fire protection sprinkler head in the

elevator shaft and elevator machine room. Connect heat detectors to shunt trip circuit breaker serving elevator.

- C. Provide fire return/recall smoke detector in each elevator lobby within five (5) feet of elevator entrance. Connect main alarm contacts of fire alarm system and auxiliary contacts to elevator controller. Provide two (2) 18 AWG in ¾-inch conduit to elevator terminals as directed by Elevator Contractor.
- D. Provide fire alarm control modules and monitoring modules as required per Specifications and codes.
- E. Provide two (2) 18 AWG wiring in ¾-inch conduit from each elevator lobby smoke detector to each elevator controller in the Elevator Machine Room.
- F. Provide dedicated fire alarm system valve tamper switch and water flow switch at the following locations:
 - 1. At the top of each elevator shaft.
 - 2. In each elevator pit.
 - 3. In each Elevator Machine Room.
- G. Provide smoke detectors at the top of each elevator shaft. Provide remote indicating lamp unit at top floor elevator lobby and connect to smoke detector.

3.4. EMERGENCY POWER PROVISIONS

- A. Feed elevator cab lights from emergency power source.
- B. Feed elevator drive(s)/controller(s) from legally required standby power supply system.

END OF SECTION

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COOLER & FREEZER WIRING
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SECTION 26 05 11 - COOLER AND FREEZER WIRING

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. Cooler and freezer wiring which includes:
 - 1. Power service connections.
 - 2. Lighting connections.
 - 3. Interconnections between remote compressors and refrigerated units.

PART 2. PRODUCTS

2.1. CONDUIT

- A. Refer to Division 26 Section 260533, "Raceways and Boxes for Electrical Systems".
- B. In cooler and freezer areas, use PVC coated rigid conduit. Whenever possible, avoid the use of surface wiring and run conduit in space behind or above insulated panels.
- C. Provide fiber nipple through wall or ceiling of siding of refrigerated areas.

2.2. OUTLET BOXES

- A. Refer to Division 26 Section 260533, "Raceways and Boxes for Electrical Systems".
- B. Provide exterior type boxes and covers for all units installed inside coolers and freezers.

PART 3. EXECUTION

3.1. INSTALLATION

- A. Coolers and freezers to be supplied and installed by other trades prewired complete with light fixtures, switch, door heating tape, all tied to central junction box. Provide all conduit and wire associated with refrigeration equipment, defrost heater, blower coil, alarm, door heaters, drain heaters, interlocks, lighting, switches, evaporator, coil fans, compressors, or any other electric devices supplied with the unit.
- B. Arrange to have all openings cut and sealed in coolers and freezers to accommodate electrical system installation by equipment supplier.
- C. Install conduit exposed on surface inside coolers and freezers parallel to room lines.
- D. Where conduit enters refrigerated areas, install fiber nipple from box outside refrigerated area to surface mounted box inside area. Provide ground conductor through nipple. After

conductors are installed, plug both ends of fiber nipple with oakum.

- E. Install wiring for blower fans, defrost heaters, lighting, switches, evaporator, coil fans, compressors, interlocks, door heaters, drain heaters, alarms, or any other electric devices supplied with the unit through the top of the cooler freezer from surface-mounted box in space above.
- F. Provide spiral heat tape applied to drain line within interior of freezer compartment.
- G. Provide electrical conduits run concealed above walk-in ceilings to serve interior lights.

END OF SECTION

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KITCHEN EQUIPMENT WIRING
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SECTION 26 05 12 - KITCHEN EQUIPMENT WIRING

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. Kitchen equipment wiring, including:
 - 1. Power service connections.
 - 2. Light switch for control of hood lights.
 - 3. Control wiring specifically shown on Electrical and/or Kitchen Equipment Drawings.
 - 4. Fire alarm connections shall be provided by the Owner's fire alarm vendor.
- B. All line and disconnect switches, safety cut-offs and fittings, convenience boxes or other electrical controls, fittings and connections will be furnished and installed under electrical contract by Division 26, unless specifically indicated otherwise in the item specifications. Starting switches for certain specified pieces of food service equipment are to be provided by Kitchen Equipment Contractor. Those starting switches, if furnished loose as standardized by Foodservice Manufacturers (other than fabricated items), shall be mounted and wired complete under Division 26.

1.3. SUBMITTALS

- A. Provide dimensioned equipment layouts, detailed shop drawings of equipment showing locations and method of installing loose equipment and making final connections, and wiring and control diagrams.

PART 2. PRODUCTS

2.1. WIRE AND CABLES

- A. Refer to Division 26 Section 260519, "Low-Voltage Electrical Power Conductors and Cables". All wiring to the kitchen equipment shall be THWN/THHN.
- B. Where heating elements are involved in equipment supplied, provide moisture resistant wire having suitable temperature rating for service conditions.
- C. All wiring in Kitchen hoods and in other high ambient temperature areas shall be of types required by NEC.

2.2. OUTLET BOXES

- A. Refer to Division 26 Section 260533, "Raceways and Boxes for Electrical Systems".
- B. In making connections to disposers, dishwashers, and similar units where moist conditions

are encountered, provide NEMA 4 boxes, covers, and fittings.

2.3. CONDUIT

- A. Refer to Division 26 Section 260533, “Raceways and Boxes for Electrical Systems”.
- B. Provide only rigid steel conduit, zinc-coated, where concealed, and shall provide only rigid steel chrome-plated where exposed. All wiring and conduit shall be run concealed wherever possible.
- C. Provide liquid tight flexible metal conduit connections to all direct connected equipment.

2.4. COVER PLATES

- A. Refer to Division 26 Section 262726, “Wiring Devices”.
- B. Provide brushed stainless steel plates for receptacles located in stainless steel backsplash.
- C. Provide weatherproof cover plates for all receptacles in damp locations.

2.5. DISCONNECT SWITCHES

- A. Refer to Division 26 Section 262816, “Enclosed Switches and Circuit Breakers”.
- B. Provide NEMA 4 type stainless steel enclosures.

2.6. CORDS AND CAPS

- A. Straight-blade Attachment Plug: NEMA WD 1.
- B. Locking-blade Attachment Plug: Match receptacle configuration at outlet provided for equipment.
- C. Cord Construction: Oil-resistant thermoset insulated Type SO multiconductor flexible cord with identified equipment grounding conductor, suitable for extra hard usage in damp locations.
- D. Cord Size: Suitable for connected load of equipment and rating of branch circuit overcurrent protection.

2.7. SWITCHES AND CONTROLS

- A. Provide recognized commercial grade signals, On-Off pushbuttons or switches, and other speed and temperature controls as required for operation of each item, complete with pilot lights and permanent graphics, conspicuously labeled, to assist the user of each item.
- B. Mount switches and controls directly adjacent to the piece of equipment for which it involves, on operator’s side of counter body apron, out of view to the public.
- C. Provide on or for each motor-driven appliance or electrical heating or control unit, a suitable control switch or starter of the proper type and rating and in accordance with

Underwriter's Code, wherever such equipment is not built in. All line switches, safety cut-outs, control panels, fuse boxes, other control fittings and connections, when not an integral part of the unit or furnished loose by the manufacturer, will be furnished and installed by the Contractor, unless otherwise specified. All electrical controls, switches, or devices provided loose for field installation as a part of the item specified be installed in the field by the contractor unless otherwise specified.

- D. Appliances shall be furnished complete with motors, driving mechanisms, starters, and controllers, including master switches, timers, cut-outs, reversing mechanisms, and other electrical equipment if and as applicable.

2.8. OTHER PRODUCTS

- A. Refer to related sections for other product requirements.
- B. Provide three- or four-wire, grounding-type receptacles for all wall and floor-mounted receptacles to be used for plug-in equipment with characteristics as noted on the Contract Drawings.
- C. Provide Hubbell, or approved equal, three-wire or four-wire grounding-type connectors and neoprene cords installed on each item of plug-in equipment, as indicated on drawings and item specifications.
- D. Provide receptacles to match the specific plugs provided as part of the plug-in equipment. Any changes in cords and plugs required in the field due to lack of coordination shall be the Contractor's responsibility.
- E. All receptacles in kitchen area shall be GFCI (Ground Fault Circuit Interrupting) protected to meet requirements of NEC – Article 210.8(B).
- F. Reduce the length of all cords furnished with the specified equipment to a suitable or appropriate length so they do not interfere with other equipment or operations.

PART 3. EXECUTION

3.1. COORDINATION

- A. Locations of outlet boxes, conduit stubs and connection points shown on drawings are for bidding purposes only. Determine exact locations for outlet boxes, conduit stubs and connection points from approved shop and setting drawings prepared by Kitchen Equipment Contractor.
- B. Confirm rating of each item of equipment with kitchen equipment supplier before installing breakers and wiring.

3.2. INSTALLATION

- A. Kitchen equipment to be supplied and set in place by other trades, complete with all motors, heating elements and automatic controls. Except where otherwise noted, motor protection switches and control stations shall be supplied as part of equipment. Provide wiring and electrical connections to kitchen equipment. Connect to panel or junction box of prewired

equipment.

- B. Rough-in location shall be within three inches of the equipment. If direct connection is required, use Sealtite. If receptacle connection is required, verify proper receptacle configuration with equipment installer.
- C. Final connections shall include extension of all service to each piece of equipment. All labor and material required to completely connect the equipment ready to operate shall be included in the final connections. All control wiring not integral with equipment shall be included.
- D. Equipment Contractor shall provide services of their representatives and/or Equipment Manufacturer's Representative at appropriate stage of construction to answer the Contractor's questions concerning the final connections. All control wiring not integral with equipment shall be included.
- E. Use wire and cable with insulation suitable for temperatures encountered in heat-producing equipment.
- F. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit in damp or wet locations.
- G. Install pre-finished cord set where connection with attachment plug is indicated or specified, or use attachment plug with suitable strain-relief clamps.
- H. Provide suitable strain-relief clamps for cord connections to outlet boxes and equipment connection boxes.
- I. Make wiring connections in control panel or in wiring compartment of pre-wired equipment in accordance with manufacturer's instructions. Provide interconnecting wiring where indicated.
- J. Install disconnect switches, controllers, control stations, and control devices such as limit switches and temperature switches as indicated. Connect with conduit and wiring as indicated.

3.3. EXHAUST HOODS

- A. For kitchen exhaust hoods, provide all required power and control wiring. This shall include (but is not limited to) the following:
 - 1. Provide switch in hoods and branch circuit for integral light fixtures.
 - 2. Provide pushbutton switch or manual starter for exhaust fan.
- B. Provide 120 volt, 20 ampere emergency branch circuit for fire suppression system. Wire automatic heat detectors or manual station; so, when activated, valve of dry chemical bottle opens, gas solenoid valve shuts down, all dampers close, exhaust and make-up fans shut down, electrical power contactor opens (integral in equipment), and building fire alarm system is activated. Provide all required wiring, conduit and final connections. Refer to wiring diagrams supplied with equipment.

- C. Provide connections to kitchen hood extinguishing systems per NFPA 96, 7-3.1.3 for alarm.
- D. Wire washdown system: Refer to schematic wiring diagrams supplied with hoods. Interconnect fire prevention system with washdown system so washdown system is activated upon alarm.
- E. Wire hood fire suppression system in accordance with the hood fire suppression manufacturer's requirements. Typical functions are: upon activation, gas solenoid valve closes, dampers close, kitchen and hood supply fans shut down, hood exhaust fan starts, electrical circuits to equipment under hood de-energize, and fire alarm system signal associated with the kitchen zone initiates an alarm. Coordinate installation with Owner furnished security/fire alarm system supplier and Contractor.

END OF SECTION

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MEDIUM-VOLTAGE CABLES
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SECTION 26 05 13 – MEDIUM-VOLTAGE 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 cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

1.3. DEFINITIONS

- A. NETA ATS: Acceptance Testing Specification.

1.4. GENERAL

- A. Definition: Medium voltage power cables shall mean all cables rated 5 kV and above.
- B. Provide all necessary cables as indicated on the drawings or as specified herein.
- C. This specification covers medium voltage conductor shielded power cable suitable for use in wet and dry locations in underground duct systems.

1.5. RATING

- A. Twenty-five (25) kV cable for use on 24.94kV grounded system.

1.6. CODES AND STANDARDS:

- A. All cables and accessories furnished under this Section shall be in accordance with the latest applicable standards of AEIC, ANSI, NEMA, IEEE, ICEA, OSHA, and the National Electrical Code. In addition, cable and accessories shall be in accordance with the requirements of local utility company. The requirements of the local utility are in addition to, and in no way a waiver of, the applicable codes and standards.
- B. Where any requirements specified herein or shown on the Contract Drawings exceed the listed standards, the Bidder shall adhere to the higher standard. In the case of conflict in requirements between two or more standards, the decision of the Engineer shall be final. Code compliance is mandatory. Nothing in the Drawings and Specifications implies acceptance of work that does not comply with Codes.
- C. Where applicable, all equipment and materials shall be listed and labeled by a nationally recognized testing laboratory with equipment listing and follow-up services.

- 1. American National Standards Institute (ANSI)

- a. ANSI C2 National Electrical Safety Code

2. National Electrical Manufacturers Association (NEMA)
 - a. NEMA WC8 Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
3. National Fire Protection Association (NFPA)
 - a. NFPA 70-1999 National Electrical Code
4. American Society for Testing and Materials (ASTM)
 - a. ASTM B-8 Concentric-Lay-Stranded Copper Conductors; Hard, Medium, or Soft.
 - b. ASTM B-231 Concentric-Lay-Stranded Aluminum Alloy 1350 Conductors.
- D. Association of Edison Illuminating companies (AEIC): AEIC CS6 EP Rubber Insulated Wire Cable.
- E. Insulated Cable Engineers Association (ICEA): ICEA S-68-516 Cables Rated 0-3500X Ozone Resistance
- F. Underwriters Laboratories (UL): UL-1072 List of Acceptable Sunlight Resistant PVC Compounds for use as insulating and/or jacketing material on listed outdoor flexible cords.
- G. AEIC CS 5-1987: Specifications for Thermoplastic and Crosslinked Polyethylene Insulated Shielded Power Cables Rated 5 through 35 kV.
- H. AEIC CS 6-1987: Specification for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 through 69 kV.
- I. IEEE 48-1990: Standard Test Procedures and Requirements for High-Voltage Air-Conditioning Cable Terminations (ANSI).
- J. IEEE 386-1995: Standard for Separable Insulated Connectors System for Power Distribution Systems above 600 V (ANSI).
- K. IEEE 404-1993: Standard for Cable Joints for Use with Extruded Dielectric Cable Rated 5000-138,000 Volts and Cable Joints for Use with Laminated Dielectric Cable Rated 2500-500,000 Volts (ANSI).
- L. IEEE 576-1989: Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in the Petroleum and Chemical Industry (ANSI).
- M. IEEE C2-1996: National Electrical Safety Code (ANSI).
- N. ICEA T-31-610-1994: Guide for Conducting a Longitudinal Water Penetration Test for Sealed Conductor.
- O. NETA ATS-1995: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

- P. NEMA WC 7-88 (ICEA S-66-524): Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- Q. NEMA WC 8-88 (ICEA S-68-516): Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- R. NEMA WC 26-90: Wire and Cable Packaging.
- S. NFPA 70: National Electrical Code.

1.7. GENERAL REQUIREMENTS

- A. All materials supplied by the Contractor shall be new, of recent manufacture, and of the highest commercial grade as specified. They shall be resistant to moisture and corrosion to withstand their environment and operational conditions with minimum maintenance and long life.

1.8. QUALIFICATIONS

- A. The manufacturer of the materials specified herein shall have at least ten years of demonstrated experience in the manufacture of the specified product.
- B. The manufacturer shall be a company specializing in the manufacture of medium voltage cable and/or accessories with minimum five years documented experience in producing cable and/or accessories similar to those specified below.
- C. The cable materials and manufacturer shall meet or exceed all applicable requirements of the latest editions of ICEA Standard S-68-516, AEIC and NEMA Standards.
- D. The cable shall be manufactured using the triple tandem extrusion process in which all layers, from the conductor to, and including, the insulation tape shield, are installed at essentially the same time without an intervening storage period on reels or other storage devices.
- E. Factory Tests:
 - 1. Cable shall be factory-tested at high voltage AC, high voltage DC, and for corona discharge in accordance with ICEA requirements.
 - 2. Certification of satisfactory completion of factory tests for cables shall be submitted to the Engineer at the time of cable delivery.

1.9. SUBMITTALS

- A. Submit product data indicating cable and accessory construction, materials and ratings.
- B. Submit Manufacturer's certificate stating factory test voltage.
- C. Submit Manufacturer's installation instructions.
- D. Submit Manufacturer's Certificate stating that medium voltage cable meets or exceeds all requirements.

- E. Manufacturer's instructions for storage, handling, protection, examination and field testing of cables and accessories before initial energization.
- F. Samples: 16-inch (400-mm) lengths of each type of cable specified.
- G. Product Certificates: Signed by manufacturers of cables and accessories certifying that the products furnished comply with requirements.
- H. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- I. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- J. Product Test Reports: Indicate compliance of cables and accessories with requirements based on comprehensive testing of current products.
- K. Medium Voltage Cable Terminating and Splicing Workman's Competency: In order to establish workman's competency regarding medium voltage cable terminating and splicing, the Contractor shall be required to submit the following within 30 days prior to commencement of termination of work.
 - 1. Documentation to verify that the individual has completed a termination and splice of the types to be installed, under the supervision of the cable accessory manufacturer, or his representative.
 - 2. Documentation that the dummy termination and splice have undergone and passed the following tests, to be performed by the splice kit supplier. These results shall be attached for review.

Test	Minimum Value
Discharge Ext. Value with 3 pc or less	13 kV
AC Withstand, 1 minute	35 kV
DC Withstand, 15 minutes	65 kV

- 3. A statement of the number of years in which the individual has been splicing/terminating medium voltage cables.
 - 4. A list of the last three jobs where specific splices/terminations were installed within the last 12 consecutive months. This list shall include splice/termination manufacturer, catalog number, cable type and the quantity installed.
- L. Maintenance Data: For cables and accessories to include in the maintenance manuals specified in Division 01.
 - 1. Include periodic tests of cables in service.
 - 2. Include operation of fault indicators, separable insulated connectors, and

accessories.

1.10. QUALITY ASSURANCE

- A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.
- 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.
 - 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.
- C. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.
- D. 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.
- E. Comply with IEEE C2 and NFPA 70.

1.11. PROJECT RECORD DOCUMENTS

- A. Submit record documents under provisions of Division 01.
- B. Accurately record exact sizes, lengths, types, quantities, and locations of cables. Indicate where all splices and terminations are located for each cable.

1.12. DELIVERY, STORAGE AND HANDLING

- A. Deliver products to site under provisions of Division 01 and comply with NEMA WC 26.
- B. Store and protect products under provisions of Division 01. Store cables and reels on elevated platforms in a dry location.
- C. Accept cable and accessories on site in manufacturer's packages and inspect for damages.
- D. Protect cable and accessories from weather by covering with opaque plastic or canvas. Provide ventilation to prevent condensation.
- E. Cable shall be stored according to manufacturer's recommendations as a minimum. In addition, cable must be stored in a location protected from vandalism and weather. If cable is stored outside, it must be covered with opaque plastic or canvas with provision for ventilation to prevent condensation and for protection from weather. If air temperature at cable storage location will be below 40 degrees F, the cable shall be moved to a heated (50 degrees F minimum) location. If necessary, cable will be stored off site.

1.13. SITE REQUIREMENTS

- A. Provide responsibility for all safety requirements on the work site.
- B. Comply with OSHA Confined Space Regulations, 8CCR 5156-5158.
- C. Barricade open utility holes and pullboxes at all times. Provide for safe flow of traffic and pedestrians.
- D. Provide for continuous, mechanically supplied, fresh air to manholes and vaults where workers are inside.
- E. All switching of existing circuits shall be performed. Verify that circuits are de-energized and locked out prior to starting work.
- F. Scheduled outages that may be required to complete the work will be coordinated with the Owner.
- G. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Architect/Engineer at least two (2) days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Engineer/Architect's written permission.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Manufacturer must be able to meet these Specifications as well as the latest edition of Association of Edison Illuminating Company (AEIC) Specification CS6 and other applicable industry standards and specifications.
- B. The proposed medium-voltage cable must be approved acceptable by local utility company.
- C. 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. Cables:
 - a. Okonite Company (The).
 - b. Prysmian (formally Pirelli) Cable Corporation; Power Cable Division.
 - c. American Insulated Wire Corporation; Leviton Manufacturing Company.
 - d. BICC Brand-Rex Company.
 - e. Carol Cable Company, Inc.
 - f. Kerite Company (The); Hubbell, Inc.
 - g. Rome Cable Corporation.

- h. Southwire Company.
- 2. Cable Splicing and Terminating Products and Accessories:
 - a. 3M Company; Electrical Products Division.
 - b. Elastimold.
 - c. Engineered Products Company.
 - d. G & W Electric Company.
 - e. Mac Products, Incorporated.
 - f. MP Husky Corporation.
 - g. Raychem Corporation; Energy Division.
 - h. RTE Components; Cooper Power Systems, Inc.
 - i. Scott Fetzer Company; Adalet-PLM Subsidiary.
 - j. Thomas & Betts Corporation.

2.2. MEDIUM VOLTAGE CABLE - SHIELDED

- A. Usage: this cable shall be used for all above and underground applications (except for jumper cable applications. See "Jumper Cable" below) and shall be contained in conduit or other raceways. It may be used in cable trays in electrical vaults only.
- B. Cable: Single conductor, insulated cable rated 25kV, 133% insulation level, ungrounded, NEC-UL Type MV-90. Sizes as indicated on the Drawings.
- C. Conductor: Soft copper, annealed, uncoated, Class B compressed or concentric stranded, having nominal direct-current resistance equal to or less than that required in Section 2.5.2 and Table 2-12 of ICEA S-68-516.
- D. Conductor Shield: Copper tape, helically applied over extruded semiconductor with resistivity requirements of Section 2.4 of ICEA S-68-516. Material shall be clean stripping from the conductor and firmly bonded to the overlying insulation.
- E. Insulation: Extruded EPR (ethylene propylene rubber), 133 percent insulation level, minimum nominal thickness of 0.220 inches, minimum insulation K factor of 50,000 megohms per 1000 foot length. Manufacturer's Certification of this value shall be a part of submittal for cable approval.
- F. Insulation Shield: the insulation shield shall consist of an extruded semiconducting layer directly over the insulation and a coated copper tape over the semiconducting covering. The tape shall be at least 2.5 mils (0.0635 mm) thick and be spiral wrapped with a 12.5 percent overlap. The insulation shield shall meet all requirements of ICEA Section 4.1.1.
- G. Jacket: Black chlorosulfonated polyethylene (CSPE), Polyvinyl Chloride (PVC) or Chlorinated Polyethylene (CPE), all rated AUSE@ with a minimum jacket thickness - 80 mils (2.03 mm), meeting all requirements of ICEA.
- H. Cable Rating: Continuous duty at 90 degrees C, wet or dry locations, suitable for underground duct installations, NEC-UL Type MV-90, Type USE.

2.3. MEDIUM-VOLTAGE CABLE - UNSHIELDED (JUMPER CABLE)

- A. Usage: This cable may only be used between equipment in the same vicinity such as between the primary switch and the transformer where adequate through-air clearance can be achieved between the conductors. In general, it is not designed for and shall not be used in metallic raceways.
- B. Cable: Single conductor, flexible, non-shielded, insulated cable-rated 25 KV, ungrounded. Sizes as indicated on the Drawings.
- C. Conductor: Soft annealed copper, uncoated, concentric stranded, having nominal direct-current resistance equal to or less than that in Section 2.5.2 and Table 2-12 of ICEA S-68-516.
- D. Conductor Shield: Extruded semiconductor with resistivity requirements of Section 2.4 of ICEA S-68-516. Material shall be clean stripping from the conductor and firmly bonded to the overlying insulation.
- E. Insulation: Extruded EPR (ethylene propylene rubber), rated at 25 KV, minimum thickness of .175 inches, minimum insulation K factor of 50,000 megohms per 1000 foot length. Manufacturer's certification of this value shall be a part of submittal for cable approval.
- F. Cable Rating: Continuous duty at 90 degrees C dry locations.

2.4. GENERAL CABLE REQUIREMENTS

- A. Cable shall be single conductor shielded, NEC UL Type MV-90, Class B stranded bare copper, covered with an extruded layer of semi-conducting ethylene-propylene based elastomer (EPR).
- B. The insulation shall be an ethylene-propylene elastomer which shall meet or exceed the electrical and physical characteristics of ICEA-S-68-516 and AEIC CS6 (latest edition). The insulation thickness shall be 115 mils for 5kV, 220 mils for 15kV, and 345 mils for 35kV class service.
- C. The insulating compound shall have a maximum ethylene content of 72% by weight and shall not contain any polyethylene.
- D. The insulation screen shall be an extruded layer of semi-conducting ethylene-propylene based material with a volume resistivity not in excess of 10 ohm-meters (at 90 degrees C) and shall be applied in accordance with AEIC CS6.
- E. Both inner and outer semi-conducting compounds shall have an elongation after air oven aging at 121 degrees C for 160 hours of 100 percent and a brittleness temperature not warmer than -50 degrees C. The semi-conducting layers and insulation shall be applied using the triple tandem extrusion process.
- F. A 5 mil base copper tape shield shall be applied over the outer semi-conducting layer with a nominal 12.5 percent overlap.

- G. The overall jacket shall be polyvinylchloride [polyethylene] applied in accordance with ICEA S-68-516 Part
- H. A permanent marking on the jacket shall indicate cable type, size, conductor type, and rated voltage.

2.5. TERMINATIONS

- A. The selected termination system shall be approved by the cable manufacturer. Possible types of acceptable terminators include:
 - 1. Potheads: IEEE 48; Class 1 termination for one conductor with porcelain insulators, cable connector and aerial lug, sealed cable entrance and support, and insulating compound.
 - 2. Porcelain Insulator Cable Terminators: IEEE 48; Class 1. Kit form, suitable for use with cable specified.
 - 3. Cast Epoxy Cable Termination: IEEE 48; Class 1. Kit form, suitable for use with cable specified, including stress cone, shield ground connection, epoxy resin molding material, and accessories and molds necessary for proper application.
 - 4. Modular Molded Rubber Termination: IEEE 48; Class 1. Kit form, suitable for use with cable specified, including stress cone, ground clamp, non-tracking rubber skirts, connector, rubber cap, and aerial lug. Termination shall be hot or cold shrink type with internal stress relief tube to distribute electric field (10% to 90% equipotential lines) over entire length of skirted insulator.
 - 5. Tape Termination: IEEE 48; Class 1. Kit form, suitable for use with cable specified, including semi-conductive tape, stress control tape, splicing tape, vinyl plastic tape, stress cone, mechanical ground straps, and cable preparation kit.
 - 6. Raychem Type HVT, heat shrinkable termination kits.
- B. Submittal for approval shall show electric field distribution (via equipotential lines) of termination device.
- C. Lugs shall be copper, long barrel, two-hole or four-hole and rated for the voltage applied. The lugs shall match the pads on the equipment to which the cable will be mounted. For example, if the equipment has a four-hole pad, the cable lug shall be four-hole type.
- D. If there will be more than one cable on an equipment pad, approved spiders (or spacers) must be used. Cable attachment to equipment must match the equipment manufacturers UL labeling requirements (if the equipment is UL listed) as a minimum. Unless the equipment is designed or listed for it, cable lugs may not be placed back-to-back on the equipment pad. In all cases, the termination and equipment must be taped with approved anti-tracking tape.
- E. Modular Molded Shrink Type Splice; IEEE 404-1986; Class 1; 25kV. Kit form, suitable for use with cable specified, including slip-on type flexible polymer or silicon rubber insulator. Splice shall be hot or cold shrink type with internal stress relief tube to distribute electric field (10 percent to 90 percent equipotential lines) over entire length of insulating material.
- F. Molded body shall contain a built-in internal semiconducting layer which covers and contacts the splice barrel and the cable insulation layer to prevent electrical stress buildup

inside the body. This semiconducting layer shall be bonded to and covered with a cured EPDM rubber or polymer insulating layer which, in turn, shall be bonded to and covered with a semiconducting layer and metallic shield and jacket.

- G. Splicing sleeves shall be long barrel type and rated for the voltage applied.
- H. The completed splice shall be approved for underground direct burial and water immersion service.

2.6. SPLICE KITS

- A. Connectors: IEEE 404, compression type, as recommended by cable or splicing kit manufacturer for the application.
- B. Splicing Products: As recommended in writing by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors and splices specified. Include all components required for complete splice, with detailed instructions.
 - 1. Combination tape and cold-shrink rubber sleeve kit with re-jacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
 - 2. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
 - 3. Pre-molded, cold-shrink rubber, in-line splicing kit.
 - 4. Pre-molded EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.
- C. Modular Molded Shrink Type Splice: IEEE 404-1986; Class 1; 25 KV. Kit form, suitable for use with cable specified, including slip-on type flexible polymer or silicon rubber insulator. Splice shall be hot or cold shrink type with internal stress relief tube to distribute electric field (10 percent to 90 percent equipotential lines) over entire length of insulating material.
- D. Molded body shall contain a built-in internal semiconducting layer which covers and contacts the splice barrel and the cable insulation layer to prevent electrical stress buildup inside the body. This semiconducting layer shall be bonded to and covered with a cured EPDM rubber or polymer insulating layer which, in turn, shall be bonded to and covered with a semiconducting layer and metallic shield and jacket.
- E. Splicing sleeves shall be long barrel type and rated for the voltage applied.
- F. The completed splice shall be approved for underground direct burial and water immersion service.

2.7. SOLID TERMINATIONS

- A. Multiconductor Cable Sheath Seals: Type recommended by Seal Manufacturer for type of cable and installation conditions, including orientation.
 - 1. Compound-filled, cast-metal body, metal-clad cable terminator for metal-clad cable with external plastic jacket.
 - 2. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and

- insulated conductors.
 - 3. Heat-shrink sheath seal kit with phase-and ground-conductor re-jacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.
 - 4. Cast-epoxy-resin sheath seal kit with wrap-around mold and packaged, 2-part, epoxy-resin casting material.
- B. Conductor Terminations: Comply with IEEE 48, as indicated. Insulation class is equivalent to that of cable. Terminations for shielded cables include a shield ground strap.
- 1. Class 1 Termination for Shielded Cable: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.
 - 2. Class 1 Termination for Shielded Cable: Heat-shrink type with heat-shrink inner stress control and outer non-tracking tubes; multiple, molded, non-tracking skirt modules; and compression-type connector.
 - 3. Class 1 Termination for Shielded Cable: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
 - 4. Class 1 Termination for Indoor Shielded Cable: Kit with stress-relief tube, non-tracking insulator tube, shield ground strap, compression-type connector, and end seal.
 - 5. Class 2 Termination for Shielded Cable: Kit with stress-relief tube, non-tracking insulator tube, shield ground strap, and compression-type connectors. Include silicone-rubber tape, cold-shrink rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
 - 6. Class 3 Termination for Shielded Cable: Kit with stress cone and compression-type connector.
- C. Termination for Non-shielded Cable: Kit with compression-type connector. Include silicone-rubber tape, cold-shrink rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

2.8. SEPARABLE INSULATED CONNECTORS

- A. Separable Insulated Connectors: Modular System complying with IEEE 386. Disconnecting, single-pole, cable terminators and matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- 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. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating, designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

- E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.
 - 1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
 - 2. Portable Feedthrough Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
 - 3. Grounding Kit: Jumpered elbows, portable feedthrough accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
 - 4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.
- F. Test-Point Fault Indicators: Arranged for installation in test points of load-break separable connectors. Self-resetting indicators capable of being installed with a shotgun hot stick and tested with a test tool. Current-trip ratings as indicated.
- G. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.9. ARC-PROOFING MATERIALS

- A. Tape for First Course on Metal Objects: Ten-mil (250 micrometer) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
- B. Arc-Proofing Tape: Fireproofing tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, compatible with cable jacket.
- C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch (13 mm) wide.

2.10. FAULT INDICATORS

- A. Indicators: Automatically-reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after the cable has faulted. Instrument immune to heat, moisture, and corrosive conditions and recommended by manufacturer for installation conditions. Indicators have current-trip ratings and quantities as indicated.
- B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage/carrying case.

2.11. SOURCE QUALITY CONTROL

- A. Test and inspect cables according to ICEA S-97-682 and ICEA S-94-649 before shipping.
- B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

PART 3. EXECUTION

3.1. EXAMINATION

- A. Examine raceways to receive medium-voltage cables for compliance with requirements for installation tolerances and other conditions affecting performance of cables. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2. CABLE PULLING

- A. Prior to pulling cable, a mandrel/swab 1/4 inch smaller than the duct diameter shall be pulled through duct run to insure adequate opening of duct run. Thoroughly swab conduits to remove foreign material before pulling cables.
- B. Cables shall not be pulled into outside (exterior) or underground systems from an outside (exterior) or underground location when the outside (exterior) air temperature is below 40 degrees Fahrenheit.
- C. Furnish all required installation tools to facilitate cable pulling without damage to the cable jacket. Such equipment is to include, but not be limited to, sheaves, winches, cable reels and/or cable reel jacks, duct entrance funnels, pulling tension gauge, and similar devices. All equipment shall be of substantial construction to allow steady progress once pulling has begun. Makeshift devices which may move or wear in a manner to pose a hazard to the cable shall not be used.
- D. Cable ends shall be sealed and firmly held in the pulling device during the pulling operation.
- E. Cable pulling shall be done in accordance with cable manufacturer's recommendations, except as modified herein, and ANSI/IEEE C2 standards. Manufacturer's recommendations shall be a part of the cable submittal. Recommended pulling tensions shall not be exceeded. Pulling bending radius shall not be less than that determined by the manufacturer of the NEC. Actual pulling tensions shall be continuously monitored and permanently recorded in a log and submitted to the Engineer at the end of the project. Restrictions of pulling bending radius dimensions shall be strictly observed. Training bending radius shall not be less than 12 times cable diameter. Any cable bent or kinked to radius less than recommended dimension shall not be installed.
- F. During pulling operation, an adequate number of persons shall be present to allow cable observation at all points of duct entry and exit as well as to feed cable and operate pulling machinery.
- G. Cable Pulling: Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before the pulling of cables. Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through the manhole opening and into the duct runs. Cable slack shall be accumulated at each manhole or junction box where space permits by training the cable around the interior to form one complete loop. Minimum allowable bending radii shall be maintained in forming such loops.
- H. Cable pulling tensions shall not exceed the maximum pulling tension recommended by the

cable manufacturer. Pulling lubricant shall be used to ease pulling tensions. Lubricant shall be of a type which is non-injurious to the cable material used. Lubricant shall not harden or become adhesive with age.

- I. Lubricants for assisting in the pulling of jacketed cables shall be those specifically recommended by the cable manufacturer. Cable lubricants shall be petroleum grease for lead-covered cables (soap-stone, graphite, or talc for rubber jacketed cables). The lubricant shall not be deleterious to the cable sheath, jacket, or outer coverings.
- J. Avoid abrasion and other damage to cables during installation.
- K. Where cables are left in manhole or switchgear overnight or more than 8 hours prior to termination, the cable ends shall be sealed with paraffin or shrink wrap caps and supported in a manner which will prevent entrance of moisture into the cable. Cable shall be terminated and energized as soon as possible.

3.3. INSTALLATION

- A. The firm shall be a company specializing in installation of medium voltage cable and accessories with a minimum of five years documented experience in installation of the type of cable and accessories described below.
- B. The electricians employed for this work shall be experienced in medium voltage cable installation. Workmen involved in splicing and termination of cables shall have been specifically trained in the procedures required for the splices and terminations used in this project. At the discretion of the Engineer, documentation of experience and/or training in medium voltage cable splicing and termination shall be furnished. At the Engineer's discretion, the electricians making up terminations or splices shall make up a sample splice and/or termination to be used to determine the capability of the electrician(s) involved.
- C. Install cables as indicated, according to manufacturer's written instructions and IEEE 576.
- D. Install exposed cables, parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Install direct-buried cables on leveled and tamped 3-inch (75-mm) bed of clean sand at bottom of trench. Separate cables crossing other cables or piping from those items by a minimum of 4 inches (100 mm) of tamped earth. Install permanent markers at ends of cable runs, changes in direction, and buried splices.
- F. Install underground line warning tape 12 inches (305 mm) above cables.
- G. Install separable insulated-connector components where indicated according to manufacturer's written instructions. Provide the following quantities of components:
 - 1. Protective Cap: Install at each Terminal Junction, one on each terminal to which no feeder is indicated to be connected.
 - 2. Portable Feed-through Accessory: 3.
 - 3. Standoff Insulator: 3.

3.4. CABLE ROUTING IN UTILITY HOLES AND EQUIPMENT

- A. Certain utility holes, as indicated on the drawings, shall have the cable looped around the walls. In such cases, the cable shall circle the manhole at least 360 degrees. Where utility holes are not to be looped, cable shall be routed on the walls with the longest distance between points of entry and exit.
- B. All new and existing cable in utility holes shall be secured to racks on the utility hole walls. Cables shall be secured to racks with split porcelain insulators and clamps. Insulator openings shall be of adequate size to contain all three phases and the ground of a given circuit. Fastening cables directly to support brackets with wire or plastic ties will not be accepted. Support cables at 4' intervals with galvanized steel racks and channels and porcelain insulators or non-metallic cable racks. Cable weight shall not rest on terminations.
- C. Cables within switchgear shall be routed in a manner which will allow adequate room for bending and terminating cables. Cables must be secured in a manner which will not result in cable weight being placed on the termination electrical joint. Cable support shall be made in a manner that does not force cable against grounded metal or which compresses cable diameter. Cable training bending radius shall be at least 12 times cable diameter.
- D. Jumper cable shall be routed in a manner that prevents it from contacting any metallic surface.
- E. Installation of cables in utility holes, handholes and vaults: Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form all cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators at a maximum of 18 inches. In existing utility holes; handholes and vaults where new ducts are to be terminated or where new cables are to be installed, the existing installation of cables, cable supports and grounding as required for a neat and workmanlike installation with all cables properly arranged and supported. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space opening for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure. (Provide cable racks in each underground structure through which cable is run.)
- F. Ground metallic non-current carrying components such as cable racks, switches, and transformers. Use a 6AWG solid copper conductor, minimum.
- G. In utility holes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.

3.5. TERMINATING AND SPLICING

- A. Cable Terminating: Protect terminations of insulated power and lighting cables from accidental contact, deterioration of coverings and moisture by the use of termination devices and materials. Install all terminations of insulated power and lighting cables (e.g. cable splices, pot heads, high voltage terminations) in accordance with the manufacturer's

requirements. Make terminations using materials and methods as indicated or specified herein or as designated by the written instructions of the cable manufacturer and termination kit manufacturer. Keep cable ends sealed prior to splicing or termination to prevent the entrance of moisture.

- B. Splices in High Voltage Cables: Splices shall be suitable for continuous immersion in water and shall be made only in accessible locations in manholes or handholes. Clearly mark splices buried directly in earth by an identification slab.
- C. Certification: High voltage cable splicer/terminator certification of competency and experience shall be submitted thirty (30) days before splices or terminations are made in high voltage cables. Splicer/termination experience during the immediate past three years shall include performance in splicing and terminating cables of the type and classification being provided under this contract.
- D. Cast-Type Splice Methods: Cast-type splice insulation shall be provided by means of a molded casting process employing a thermosetting epoxy resin insulating material which shall be applied by a gravity-poured method or by a pressure-injected method. The component materials of the resin insulation shall be in a packaged form ready for convenient mixing without removing from the package. Do not allow the cables to be moved until after the splicing material has completely set.
- E. Kit Methods: High voltage splices shall be made using kit which shall be the product of one Manufacturer and shall have the approval in writing of the manufacturer of the cable which is to be spliced. Provide the Contracting Officer Quality Control Representative with a copy of the Manufacturer's instructions before splicing is started. Splices shall be made only in utility holes and handholes.
- F. Splices in Shielded Cables: Splices in shielded cables shall include covering the spliced area with metallic tape, or like material, to the original cable shield and by connecting it to the cable shield on each side of the splice. Provide a No. 6 AWG bare copper ground connection brought out in a watertight manner and grounded to a 3/4-inch by 10-foot ground rod as part of the splice installation. Wire shall be trained to the sides of the enclosure in a manner to avoid interference with the working area.
- G. Splices are to be held to a minimum. Splice locations shall be determined by cable lengths available, pulling conditions and termination points. Splice locations are to be listed by the Contractor prior to cable purchase and a listing of such locations submitted to the Engineer for approval before final cable lengths are determined.
- H. Only experienced electricians shall be employed in this phase of the work. Refer to Quality Assurance above.
- I. Follow cable manufacturer's and splice or termination manufacturer's installation instructions and ANSI/IEEE C2 standards.
- J. Clean, white lint-free gloves shall be used to handle the end of the cable during tape wrapping procedures.
- K. Termination or splicing of the copper conductors (both power and ground conductors) shall be made only with tool-applied compression (swaged) fittings.

- L. Ground system connections:
 - 1. Cable to Bus: Compression cable fitting bolted to bus with lock washers under nut.
 - 2. Cable to Ground Rod: Approved bolted fitting with backing plate between cable and rod.
- M. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware according to manufacturer's written instructions.
- N. Splice or termination failure upon high potential acceptance test will require complete reconstruction of the joint to Manufacturer's Specifications. Make sure that there is enough free cable at each termination or splice for two more terminations or splices to be performed.
- O. Install Scotch #70 tape for anti-tracking on all exposed terminations.
- P. All splices and terminations are to be tagged using embossed plastic tags with plastic attachment devices indicating date splice or termination was made, name of electrician involved, name of Contractor installing cable, feeder number and circuit to and from data.
- Q. All cable splices in manholes shall be supported on both sides of the splice within 2'0" of the splice. Splices shall not rely on cable for support.
- R. Lugs shall be bolted to termination pads in equipment using corrosion-resistant bolts, nuts, and washers. Use Belleville washers for bolting aluminum to aluminum, and lock washers for bolting copper to copper or as recommended by equipment manufacturer. Washers shall be in the lug side. Torque to Manufacturer's recommendations.
- S. Install splices at pull points and elsewhere as indicated. Use standard kits. Comply with kit manufacturer's written instructions.
- T. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits. Comply with kit manufacturer's written instructions and with classes of terminations indicated.

3.6. FIRE-PROOFING AND ARC PROOFING

- A. Fireproofing (Arc Proofing) of Cables in Utility Holes, Handholes, and Vaults: All wire and cables which will carry current at 2200 volts or more in manholes, handholes, and vaults shall be fire-proofed.
- B. Exposed cables in utility holes shall be fireproofed. Entire installation shall conform to Manufacturer's recommendations.
- C. Arc proofing material shall be Scotch #77 electrical arc and fireproofing tape, or approved equal.
- D. Install the fireproofing on the cables as follows:

1. Install tightly applied fireproofing tape, approximately 1/16-inch thick by 1-1/2 inches wide minimum, around each feeder spirally on one-half-lapped wrapping.
 2. Install the tape with the coated side towards the cable and extend it not less than one inch into each duct.
 3. Install random wrappings of Scotch #69 glass cloth tape around the installed fireproofing tape per Manufacturer's instructions to prevent it from unraveling.
- E. Fireproofing Tape: Strips of fireproofing tape approximately 1/16-inch thick by 3 inches wide shall be wrapped tightly around each cable spirally in half-lapped wrapping, or in two butt-joined wrappings with the second wrapping covering the joints in the first. The tape shall be applied with the coated side toward the cable and shall extend one-inch into the ducts. To prevent unraveling, the fireproofing tape shall be random wrapped the entire length of the fireproofing with pressure sensitive glass cloth tape. The fireproofing tape shall consist of a flexible, conformable fabric having one side coated with flame retardant flexible, polymeric fabric having one side coated with flame retardant, flexible, polymeric coating and/or a chlorinated elastomer not less than 0.050 inch thick and shall weigh not less than 2.5 pounds per square yard. The tape shall be noncorrosive to cable sheath, shall be self-extinguishing, and shall not support combustion. The tape shall not deteriorate when subjected to oil, water, gases, salt water, sewage and fungus.
- F. Arc Proofing: Arc-proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials, unless otherwise indicated. Apply as follows and as recommended by manufacturer of arc-proofing tape:
1. Clean cable sheath.
 2. Wrap metallic cable components with 10-mil (250-micron) 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 1-inch-(25-mm-) wide bands of half-lapped, adhesive, glass-cloth tape 2 inches (50 mm) on center.

3.7. PHASING

- A. Verify by hot phase test that cables on loop and tie circuits are matched phase-to-phase at every splice or termination that occurs at an open point. Use an approved live-line phasing meter and follow safety and switching procedures. This test may only be performed by personnel experienced in and qualified for testing of energized circuits. Do not rely on color markings for assurance of proper phasing.
- B. Verify correct phase rotation when cables on radial circuits are replaced. Use approved secondary voltage rotation tests or verify that the rotation of existing motors is correct.

3.8. FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent testing agency to perform field quality-control testing.
- B. Testing: On installation of medium-voltage 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.
2. Certify compliance with test parameters.
- C. Correct malfunctioning cables and accessories at project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.
- D. Test and inspect cables according to NEMA WC 7 (ICEA S-66-524) and NEMA WC8 (ICEA S-68-516) before shipping.
- E. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).
- F. Tests shall be performed on completed cable in accordance with ICEA S-68-516 and AEIC CS6 (latest edition) as specified.
- | | | |
|----|-------------------------------|---|
| 1. | Conductor Resistance | per AEIC Paragraph 1.2 |
| 2. | AC Withstand (5 minutes) | 5 kV - 22 kV
15 V - 44 kV
35 kV - 69 kV |
| 3. | IR Constant (at 15.6 C), min. | 50,000 megohms - 1000 feet |
| 4. | DC Withstand (15 min.) | 5 kV - 45 kV
15 V - 80 kV
35 kV - 125 kV |
| 5. | Partial Discharge | Per AEIC, 5 pc max. at
4 times rated voltage |
- G. Test Reports: Certified test reports shall be furnished for all cables.
- H. Field inspection and testing will be performed under provisions of Division 01.
- I. Inspect exposed cable sections for physical damage. Verify that cable is connected according to Drawings and that shield grounding, cable support, and terminations are properly installed.
- J. Perform DC high potential test of each conductor, with other conductors grounded, in accordance with the manufacturer's recommendations and IEEE Standard 400, Article 5 – “Direct Voltage Testing”. Apply test voltage to conductors in at least eight equal increments to maximum test voltage. Record leakage current at each increment, allowing for charging current decay. Hold maximum test voltage for ten minutes.
- K. Record results of test in tabular form and in plots of current versus voltage for incremental voltage steps, and current versus time (30 second intervals) at maximum voltage. Curves shall be identified with the cable to which they apply and shall be certified. Time of day, outside temperature and humidity at time of each test shall appear on each curve sheet.
- L. Perform shield continuity tests.
- M. Perform phasing checks.
- N. If any primary cable fails, or tests, in the opinion of the Owner, unacceptable cable defects,

all cables in that conduit between the nearest pulling points on each side of the failure shall be removed. If, in the opinion of the Owner, other cables that may have been installed in the same duct are not damaged, they may be re-installed, but the failed cable shall be replaced with new cable without additional charge.

- O. After replacement of the faulty cable, and any other damaged cables, all cables of the circuit in that conduit shall be re-tested. If the cable fails again, or if tests, in the opinion of the Architect, show unacceptable cable defects, all cables shall be replaced without charge and this procedure shall be repeated until tests prove satisfactory.

3.9. CABLE IDENTIFICATION AND LABELING

- A. Provide the following information on cable identification label:
 - 1. Main feeder circuit breaker number.
 - 2. Phase.
 - 3. To and From Data.
- B. Install cable labels on each conductor at each cable termination, each cable splice, in each manhole and in each pullbox. Additionally, at these locations, provide one inch (1") colored vinyl plastic electrical tape wrap identification, (Scotch 35 or approved equal) around each conductor and cable as follows:
 - 1. 25 kV individual conductor system:
 - a. A - Phase - one (1) red wrap.
 - b. B - Phase - two (2) red wraps with ½-inch space between wraps.
 - c. C - Phase - three (3) red wraps with ½-inch space between wraps.
 - 2. 25 kV multi-conductor cable system - three (3) red wraps with no space between wraps.
- C. See paragraph above under "Terminating and Splicing" for splice label requirements. This is in addition to identification labels.
- D. During entire cable installation, phasing of conductors shall be maintained and identified. Where final connections to equipment are made, phasing shall be verified and proper phase rotation determined prior to connection.
- E. Identify cables as to manufacturer, year, voltage, size, temperature, rating and ampere capacity. If such identification is not visible on the surface, the information shall be supplied on an engraved lamicoid tag permanently secured to the cable in each accessible location.
- F. Identify cables with circuit number and last and next accessible location at each substructure with an engraved lamicoid nameplate.
- G. Cables shall be identified in every manhole and pullbox by voltage, circuit name, and location of next accessible point. Identification tags shall be stamped lead or engraved lamicoid nameplate, red with white letters, approximately three-inch by five-inch (3-inch x 5-inch), fastened with #12 copper wire.

3.10. PROTECTION

- A. Provide final protection and maintain conditions, in a manner acceptable to Manufacturer and Installer, to prevent entrance of moisture into the cables and to ensure medium-voltage cables are without damage or deterioration at the time of Substantial Completion.

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. DEFINITIONS

- A. AWG: American Wire Gauge.
- B. MC: Metal-clad.
- C. RoHS: Restriction of Hazardous Substances.
- D. VFC: Variable-frequency controller.

1.4. ACTION SUBMITTALS

- A. Product Data: Provide for each type of product including but not limited to conductors, cables, and connectors.

1.5. 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 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. B3: Standard Specification for Soft or Annealed Copper Wire
 - 2. B8: Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
 - 3. D753: Standard Specification for General Purpose Polychloroprene Jacket for Wire and Cable
 - 4. B800 Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes.
 - 5. B801 Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation.
 - 6. B836 Standard Specification for Compact Round Stranded Aluminum Conductors Using Single Input Wire Construction.
- 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. WC70: Power Cables Rated 2000 Volts or Less for the 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
- L. UL Labels: Provide wiring, cabling and connector products which are UL listed and labeled.

1.6. DELIVERY, STORAGE, AND HANDLING

- A. Deliver wires and cables according to NEMA WC 26, Binational Wire and Cable Packaging Standard.
- 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.

1.7. 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.

1.8. PROJECT CONDITIONS

- A. Verify that field measurements are as shown on the Drawings.
- B. Conductors are based on the following materials, sizes as indicated on the Contract Drawings:

Application	Conductor Material	Remarks
Normal Power Supply Service	Aluminum	
Fire Pump Service and Feeder	Copper	
Feeder Circuits Less than 100A	Copper	
Feeders Circuits 100A and Greater	Aluminum	Note 1
Branch Circuits	Copper	Note 2
Notes: 1. Provide copper conductors where required by equipment manufacturer. 2. Refer to “Wire and Insulation Applications” in Part 3 of this Section for branch circuit conductor sizing based on home run length and circuit length.		

- 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. 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. Wires and Cables:
 - a. American Insulated Wire Corp.
 - b. BICC Brand Rex Company.
 - c. CME Wire and Cable.
 - d. Colonial Wire Company.
 - e. Encore Wire Corporation.
 - f. General Cable.
 - g. Senator Wire & Cable Company.
 - h. Southwire Company.
 2. Connectors and Accessories for Wires and Cables:
 - a. 3M Company; Electrical Products Division.
 - b. AMP Incorporated.
 - c. Buchanan.
 - d. General Signal; O Z/Gedney Unit.
 - e. Greaves Corporation.
 - f. Ideal Industries.
 - g. Monogram Company; AFC.
 - h. NSI Industries, Inc.
 - i. Square D Company; Anderson.
 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.
 4. Metal Clad (MC) Connectors
 - a. Arlington Industries, Inc.
 - b. Bridgeport.
 - c. Crouse-Hinds.
 - d. Thomas & Betts.

2.2. GENERAL CONDUCTOR REQUIREMENTS

- A. UL-listed building wires and cables with conductor material, insulation type, cable construction and rating as specified herein.
- B. Conductors shall meet or exceed requirements of all applicable ASTM specifications, UL Standard 83, UL Standard 1581, NEMA WC 70, Federal Specification A-A-59544 and shall be RoHS/REACH Compliant.
- C. Conductor Insulation:
 - 1. Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.
 - 2. Type THHN and Type THWN-2: Comply with UL 83.
 - 3. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
 - 4. Type XHHW-2: Comply with UL 44.
- D. Conductors shall be minimum of 12 AWG, unless otherwise required by equipment manufacturer.
- E. Conductors shall be solid for 10 AWG and smaller, and stranded for 8 AWG and larger, unless otherwise indicated herein or on the Contract Drawings.
- F. Conductors shall be stranded for connections to the following equipment:
 - 1. Motors (including fans, pumps, etc.)
 - 2. Site lighting fixtures (pole-mounted)
 - 3. Surge protective devices
 - 4. Transformers
 - 5. Variable frequency controllers
- G. 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. 120/208-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. 277/480-Volt, 3-Phase, 4-Wire System:
 - a. Phase A: Brown
 - b. Phase B: Orange
 - c. Phase C: Yellow
 - d. Neutral: Gray
 - e. Ground: Green
 - 3. 120/240-Volt, 1-Phase, 3-Wire System:

a.	Phase A:	Black
b.	Phase B:	Red
c.	Neutral:	White
d.	Ground:	Green

2.3. COPPER BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. RoHS compliant.
 - 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- C. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors. 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.

2.4. ALUMINUM BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. RoHS compliant.
 - 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- C. Conductors: Aluminum, complying with ASTM B800 and ASTM B801.

2.5. VFD CABLE

- A. Description: Type TC-ER cable designed for use with variable frequency controllers (VFCs), with extra-flexible stranded copper conductors, oversized crosslinked polyethylene (XLPE) insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer polyvinyl chloride (PVC) or thermoplastic elastomer (TPE) jacket.
- B. Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.

2.6. 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 pads or terminals. Not approved for splicing.
- D. Spring Wire Connectors: Not acceptable.
- E. Mechanical Connectors: Bolted type tin-plated; high conductivity copper alloy; spacer between conductors; beveled cable entrances.
- F. 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.
- G. 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.
- H. 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.
- I. Wire Nut Connectors:
 - 1. Description: Twist-on wire connectors for branch circuit conductors 10 AWG and smaller with a color-coded housing.
 - 2. Construction: Flame-retardant polypropylene housing, rated for 105 degrees Celsius. Zinc-plated steel insert. Square-wire spring to maintain secure positive grip that will not relax over time, no pre-twisting required.
 - 3. Dimensions: Connectors shall be appropriately sized according to manufacturer's recommendation for the suitable wire sizes and voltage rating (600 volts minimum).
 - 4. Quality Assurance:
 - a. UL Listed to 486C and 94V-2 Flame Rating.
 - b. CSA Certified to C22.2 No. 188
 - c. RoHS Compliant
 - 5. Special Features:
 - a. Wire connectors for making grounding connections shall have green-colored housing and shall have opening at end of connector for grounding conductor to pass through for connection to metallic outlet boxes.
 - b. Wire connectors for all exterior and underground work and work in damp/wet interior locations shall be pre-filled with silicone-based sealant to protect against moisture and corrosion, and shall be UL Listed to 486D

- for use in damp/wet locations, including direct burial applications.
 - c. Wire connectors for high temperature applications, e.g. high-wattage lighting fixtures and signs, shall be UL listed to 150 degrees Celsius, and shall have a black fire-retardant plastic shell design to withstand heat build-up.
- 6. Basis of Design: Provide products by Ideal Industries, Inc. or approved equal.
- J. Gel Tap Splices (for Conductors 10 AWG and Smaller in Damp/Wet Locations)
 - 1. Description: Gel sealant filled splice for buried, underground, and overhead applications for low voltage (1000V or less) circuits. Protects connections from moisture ingress, corrosion, and pollution.
 - 2. Construction: Range-taking mechanical connector made of aluminum accepts both aluminum and copper conductors. Molded cover of UV stable, impact resistant polypropylene provides rugged protection. Silicone gel is hydrophobic dielectric insulation and provides constant pressure on cable and connector to provide water seal. Seal is specially formulated for high temperature environments.
 - 3. Dimensions: Splices and connectors shall be appropriately sized according to manufacturer's recommendation for the suitable wire sizes and voltage rating.
 - 4. Quality Assurance: UL listed.
 - 5. Special Features: Silicone gel shall easily peel away from connector, leaving a clean connection. Splices shall be rated for temperatures from -40 degrees Celsius to 90 degrees Celsius.
 - 6. Basis of Design: GTAP Series as manufactured by Raychem/Tyco, or approved equal.
- K. Insulated Connectors (for Conductors 8 AWG and Larger in Dry Locations)
 - 1. Description: Multi-conductor connectors for low voltage (600V or less) circuits, insulated with high-dielectric strength plastisol, molded for precise fit and supplied with removable access plugs over the hex screws.
 - 2. Construction: Range-taking mechanical connector made of aluminum accepts both aluminum and copper conductors. Molded cover of UV stable, impact resistant polypropylene provides rugged protection. Mounting holes at each end of the connector for direct isolated mounting to wiring trough, panelboard, or wireway.
 - 3. Dimensions: Splices and connectors shall be appropriately sized according to manufacturer's recommendation for the suitable wire sizes, quantities, and voltage rating.
 - 4. Quality Assurance: UL listed. UV resistant.
 - 5. Special Features: Connectors shall be rated for temperatures from -45 degrees Celsius to 90 degrees Celsius.
 - 6. Basis of Design: IPLM/IPLMD Series as manufactured by Polaris, or approved equal.
- L. Gel Filled Insulated Connectors (for Conductors 8 AWG and Larger in Damp/Wet Locations)
 - 1. Description: Multi-conductor connectors for low voltage (1,000V or less) circuits, insulated with high-dielectric strength plastisol, molded for precise fit and supplied with removable access plugs over the hex screws. Gel-filled for damp/wet or

- submersed locations to protect connections from moisture ingress and corrosion.
2. Construction: Range-taking mechanical connector made of tin-plated aluminum accepts both aluminum and copper conductors. Molded cover of UV stable, impact resistant polypropylene provides rugged protection. Cable entry ports and hinged screw port caps shall be sealed with hydrophobic dielectric gel insulation.
3. Dimensions: Splices and connectors shall be appropriately sized according to manufacturer's recommendation for the suitable wire sizes, quantities, and voltage rating.
4. Quality Assurance: ANSI C119.1 for complete unit, ANSI C119.4 for connector, ASTM D543 for chemical resistance, ASTM G-53-95 and ASTM D-638-95 for UV resistance.
5. Special Features: Silicone gel shall be easily removed from conductor for re-entry. Connectors shall be rated for temperatures from -40 degrees Celsius to 95 degrees Celsius.
6. Basis of Design: GPRT Series as manufactured by Raychem/Tyco, or approved equal.

2.7. METAL CLAD (MC) CABLE

- A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
- B. Standards:
 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 2. Comply with UL 1569.
 3. RoHS compliant.
 4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- C. Cable Types:
 1. Single circuit with color-coded conductors.
 2. Luminary: Cables serving lighting fixtures and/or lighting control devices with 0-10V dimming controls shall have 16 AWG copper TFN insulated single conductors within interlocked armor. Control conductors shall have purple and pink insulation/jacketing.
- D. Conductors:
 1. Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
 2. Only cables with conductor sizes 12 AWG and 10 AWG shall be permitted.
 3. Conductors shall be protected by an anti-short bushing at each termination.
- E. Ground Conductor:
- F. Conductor Insulation: Type THHN/THWN-2. Comply with UL 83.
- G. Armor: Steel, interlocked.

2.8. METAL CLAD (MC) CABLE CONNECTORS

A. Snap-In Connectors

1. Snap-in connectors for metal clad cable shall be constructed of die-cast zinc, shall be compatible with steel and aluminum cables, and shall have the following features:
 - a. Insulated throat
 - b. Removable ring to secure connector to box
 - c. Angled, two-prong clip to secure cable
 - d. Removable screw to secure cable clip
2. Snap-in connectors shall be available in a variety of sizes and configurations to accommodate different cable sizes/diameters, wire counts, cable counts, etc.
3. Single connectors shall be compatible with 1/2-inch knockouts. Duplex connectors shall be compatible with 3/4-inch knockouts.
4. Provide SNAP²IT connectors as manufactured by Arlington Industries, Inc., or approved equal by listed manufacturer.

B. Lock-Nut Connectors

1. Straight connectors shall be one-piece spring-steel, set screw design with nylon insulator and locknut. Provide ACB series, as manufactured by Crouse-Hinds, or approved equal.
2. 45 and 90 degree connectors shall be die cast zinc, clamp type with insulated throat and locknut. Provide ACBXX45 or ACBXX90 series as manufactured by Crouse-Hinds, or approved equal.

2.9. 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. All conductors shall be of the size indicated on the Contract Drawings unless otherwise required by the National Electrical Code or the equipment manufacturer. Any discrepancies shall be brought to the attention of the Architect.
- B. No branch circuit wires smaller than 12 AWG shall be used unless otherwise indicated or required by the equipment manufacturer.
- C. Conductors 8 AWG and larger shall be stranded. Conductors 10 AWG and smaller shall be solid except as otherwise indicated in Part 2 of this Section.
- D. Control wiring shall not be less than 14 AWG and shall be color coded using colors impregnated into the insulation. All control wiring shall be color coded with wires of colors different from those used to designate phase wires.
- E. Wiring for general 15 and 20 amp branch circuit work shall be as follows unless otherwise indicated:

HOME RUN LENGTH AND WIRE SIZE				CIRCUIT LENGTH AND WIRE SIZE			
120 Volt		277 Volt		120 Volt		277 Volt	
0 – 60 '	12AWG	0 – 175 '	12AWG	0-100 '	12AWG	0 – 200 '	12AWG
60 – 100 '	10AWG	175 - 350'	10AWG	100' & Up	10AWG	200 ' & Up	10AWG
100' & Up	8AWG	350> & Up	8AWG				

- F. Circuit length as given above shall be the wire length between the first and last outlet on the circuit. Home run length as given above shall be the wire length between the first outlet and the panelboard. In accordance with the above, where the size of branch circuit conductors is increased by the minimum required by the NEC for the branch circuit rating, ensure that the termination provisions of all equipment connected to such circuits are listed as suitable for the conductor sizes involved.
- G. Conductors shall be continuous from outlet to outlet and from terminal board to point of final connection, and no splice shall be made except within outlet or junction boxes.
- H. Connections from the load side of variable frequency controllers to equipment shall utilize type TC-ER conductors suitable for VFCs as specified herein.

- I. All circuits for underground exterior electric work shall be 10 AWG (minimum) and contain a 10 AWG (minimum) copper grounding conductor. All exterior wiring shall be installed in conduit as specified above, unless otherwise noted on the Drawings.
- J. 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.
- K. Wiring shall be tagged at terminations, in pull boxes, junction boxes, outlet boxes, panelboards, etc.
- L. All emergency wiring shall have the same color coding but shall clearly be identified as emergency in all outlets, fixtures, etc.
- M. Switch leg wire shall be labeled with “S” tag.
- N. 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.
- O. Joints of 8 AWG and larger shall be of the type indented into the conductor by means of a hand or hydraulic pressure tool. Connectors shall be Burndy Hy dent, T&B Sta Kon, or equivalent. Connectors for control wiring shall be Burndy Hy Lug, or equivalent.

3.4. MC CABLE APPLICATIONS

- A. MC cable shall be permitted only where concealed above accessible ceilings and/or within drywall partitions and in accordance with the requirements of Division 26 Section 260533, “Raceways and Boxes for Electrical Systems”.
- B. MC Cable shall be allowed for connections within a room from a junction box to lighting fixtures.
- C. Conduit home runs shall be in electrical metallic tubing (EMT).
- D. MC cable shall be allowed from a junction box within a room to receptacles in the same room.
- E. MC cable shall not be allowed to cross one room to another room whether the wall between two rooms goes up to slab or not. If the rooms are identified as two separate rooms, MC cable shall not be used between the two rooms.
- F. MC cable shall not be used between two receptacles when they are in two separate rooms, on the same wall.
- G. Provide anti-short bushings for all MC cable terminations.
- H. Cables shall be supported with appropriate hangers; tie wire is not acceptable.
- I. MC cable shall not be used to support other cables/wires.

3.5. INSTALLATION

- A. Install wires and cables as indicated, according to manufacturer's written instructions and NECA's Standard of Installation.
- B. 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.
- C. 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.
- D. Install exposed cables, parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Division 26 Section 260500, "Common Work Results for Electrical" and Division 26 Section 265029, "Hangers and Supports for Electrical Systems".
- F. Seal around cables penetrating fire rated elements according to Division 26 Section 260528, "Firestopping for Electrical Systems".
- G. Identify wires and cables according to Division 26 Section 260553, "Identification for Electrical Systems".
- H. Conductors installed in parallel shall be of equal lengths.
- I. Wiring at Outlets: Install with at least 6 inches (150 mm) of slack conductor at each outlet in accordance with Article 300.14 of the National Electrical Code.
- J. 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.
- K. 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 conductors. Wire pulling lubricants, if used, shall conform to UL requirements applicable to the various insulations and raceway materials. The lubricants shall be certified by the manufacturer to be non-injurious to such insulation and materials.
- L. Each cable shall be labeled at terminals and at all accessible points in equipment and in pull boxes. Each wire shall be labeled at both ends. Labels shall be self-sticking wire markers.

- M. For rubber and plastic-covered wire and cable, pulling compound Ideal Yellow 77 may be used.
- N. 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 wires 4/0 AWG and smaller. Two-hole lugs for all wires 250 kcmil AWG and larger.
- O. Install wires and cables using braided rope larger than the cable being pulled to keep twists to a minimum.
- P. Provide an insulated green equipment grounding conductor (EGC), sized per NEC, for all feeder and branch circuits, shown or not shown.
- Q. Multi-wire branch circuits shall not be permitted. Provide a separate insulated neutral (grounded) conductor for all feeder and branch circuits requiring a neutral connection.
- 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 of types required by the NEC and shall be listed for the application.
- U. No conductors shall be drawn into conduit until all work, which may cause cable damage, is completed.
- V. All wiring in lighting fixture channels, over boilers and breechings, in Kitchen hoods, and in other high ambient temperature areas, shall be of types required by NEC and shall be listed for the application.
- 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.
- X. All cable runs shall contain S loops or other means to accommodate expansion or contraction as required.
- Y. Cable bends will have a radius not less than the value recommended by the cable manufacturer.
- Z. All labels shall be of durable material and securely fastened to the cable.
- AA. Wiring of different system voltages shall not be mixed at pull boxes enclosures, surface metal raceway, wire troughs, etc., unless a barrier (separator) is provided between the differing systems.

3.6. CONNECTIONS

- A. Conductor Splices: Keep to 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. Apply oxide inhibitor in each termination for aluminum conductors per manufacturer's instructions.
- E. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer.
- F. 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.
- G. Wire splices and taps shall be adequate to carry full current rating of 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 10 AWG and smaller: Provide wire nut connectors as specified in Part 2 of this Section.
 - 2. Wire Sizes 8 AWG and Larger: Provide insulated connectors as specified in Part 2 of this Section.
- K. Thoroughly clean wiring prior to installing lugs or connectors.

3.7. IDENTIFICATION

- A. All building wire and cable shall be color-coded to identify the electrical system(s) as specified. Where color-coding is field-applied, the same shall be accomplished with colored electrical tape wrapped concentrically around each conductor in half-lapped turns, for at least the last six (6) inches of the conductor. One turn around the conductor is not acceptable.
- B. Identify wire and cable using Thomas and Betts Type WM vinyl markers.
- C. 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.

- D. Provide identification tags on each conductor entering each panelboard, switch, junction box, and pull box to identify conductor.
- E. Comply with the requirements of Division 26 Section 260553, “Identification for Electrical Systems”.
- F. 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 cables.
 - 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.

3.8. FIELD QUALITY CONTROL

- A. Visual and Mechanical Inspection:
 - 1. Inspect for defects and physical damage, labeling, and compliance with requirements of drawings and schedules.
 - 2. Clean conductors using Manufacturer’s approved methods and materials.
 - 3. Verify that conductors are correct size and are terminated with appropriately sized lugs.
 - 4. Verify that conductors are correct color for phase identification.
 - 5. Verify that conductors are labeled to identify circuit designation.
 - 6. Verify that neutral conductors are only terminated at neutral lugs/bus, and that grounding conductors are only terminated at grounding lugs/bus.
 - 7. Verify that oxide inhibitor is provided at all terminations for aluminum conductors.
- B. Electrical Tests: Upon installation of conductors and before electrical circuitry has been energized, provide the following minimum inspections and tests according to manufacturer's written instructions to ensure conductors are operational within industry and manufacturer's tolerances, are installed according to the Contract Documents, and are suitable for energizing.
 - 1. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing. 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.
 - 2. Inspect accessible components for cleanliness, mechanical and electrical integrity, and damage or deterioration.
 - 3. 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.
 - 4. Verify continuity of each conductor.
 - 5. Insulation Resistance Testing: Perform megohm meter tests of all service and feeder circuits, including each phase, neutral, and grounding conductor, as follows:
 - a. Minimum Test Voltage: 1000 Vdc.
 - b. Minimum Insulation Resistance: 1 megohms.
 - c. Duration of Each Test: 1 minute.
 - d. Temperature Correction: Correct results for test temperature deviation

- from 20 degrees C standard.
 - e. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - f. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
6. Infrared Scanning: Perform an infrared scan of each splice and termination in conductors 3 AWG and larger, as follows:
- a. Remove equipment covers so terminations are accessible to scanner.
 - b. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values.
 - c. Provide calibration record for device.
 - d. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - e. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
7. Test Labeling: On satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.

END OF SECTION

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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 01.
- 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 installation with the following Divisions:
 - a. Division 11 for food service equipment piping.

- b. Division 22 for domestic and/or sanitary piping.
- c. Division 23 for condensate piping.

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 (2) 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 Pyrotenax USA Inc.
 - 4. Caloric, Inc.
 - 5. Chromalox; Wiegard Industrial Division; Emerson Electric Company.
 - 6. Copperheat 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-regulation 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. Where electrical heat tracing is installed on steam piping or other piping where temperatures may exceed 150 degrees F, electric heat trace shall be rated for 300 degrees F.
- D. The heater shall operate on line voltages of 120 volts without the use of transformers.
- E. 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

- F. Power connection, end seal, splice and tee kit components shall be applied in the field.
- G. 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. 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. Do not install heating cable mats across expansion, construction, or control joints.
- E. 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.

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 rating 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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GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
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SECTION 26 05 26– GROUNDING AND BONDING FOR ELECTRICAL 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.
- B. Related Sections include the following:
 - 1. Division 26 Section 260519, “Low-Voltage Electrical Power Conductors and Cables”, for conductor and cable requirements.

1.2. SUMMARY

- A. This Section includes grounding of electrical systems and equipment and basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other Sections of these Specifications.
- B. Bond the electrical service system neutral at service entrance equipment to grounding electrodes and metallic water service as supplementary.
- C. Bond each separately-derived system neutral to nearest grounding system.
- D. 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. DEFINITIONS

- A. EGB: Electrical grounding busbar.
- B. EGC: Equipment grounding conductor.
- C. GEC: Grounding electrode conductor.
- D. PBB: Primary bonding busbar.
- E. SBB: Secondary bonding busbar.
- F. SSBJ: Supply-side bonding jumper.

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 grounding rods, conductors, connectors and connection materials, and grounding fittings. Submit ground system manufacturer's recommended installation

procedure for review.

- C. Field tests and observation reports indicating and interpreting the test reports for compliance with performance requirements, certified by Testing Agency.

1.5. 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 of this Section.
- 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.

1.6. PROJECT RECORD DOCUMENTS

- A. Accurately record actual locations of grounding electrodes and all primary grounding locations (i.e., grounding busbar location(s), water service connection(s), gas service connection, building steel, test wells, 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. Erico Inc.; Electrical Products Group.

2. Harger Lightning and Grounding; Harger, Inc.
3. Heary Brothers Lightning Protection Co.
4. Ideal Industries, Inc.
5. ILSCO.
6. O-Z/Gedney Co.
7. Racor, Inc.
8. 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, “Low-Voltage Electrical Power Conductors and Cables”. Conform to NEC Table 8, except as otherwise indicated, for conductor properties, including stranding.
- B. Equipment Grounding Conductors: Size as indicated on the Drawings, or as required by National Electrical Code (NEC) Table 250-122, whichever is larger. Insulated with green color insulation.
- C. Grounding Electrode Conductors: Size as indicated on the Drawings, in the Specifications, or as required by National Electrical Code (NEC) Table 250-66, whichever is larger. Insulated with green color insulation, unless installed in direct contact with earth, in which case conductors shall be bare.
- D. Underground Conductors: Bare, tinned, stranded, 4/0 AWG size minimum, except as otherwise indicated.
- E. 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 ¼-inch thick x 2-inches, length as required.
- B. Braided Bonding Jumpers: Copper tape, braided 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 lock-washers 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.

2.6. GROUNDING ELECTRODES AND TEST WELLS

A. Grounding Rods: Copper-clad rod with rigid steel core.

1. Size: 3/4 inch by 120 inches (19 by 3000 mm). Provide the number of rods required to obtain proper ground resistance.
2. Rods shall have a minimum of ten (10) mils of copper.
3. Ground rods shall be UL listed #467.

B. Test Wells: Provide as detailed on Drawings.

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.
 - g. Metal-clad (MC) cable runs.
 2. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.
 3. Water Heater and Heat-Tracing Circuits: Install a separate equipment grounding conductor to each electric water heater, heat-tracing assembly, and antifrost heating cable. Bond conductor to heater units, piping, connected equipment, and components.
- B. Telecommunications System Grounding:
 1. Provide one (1) primary bonding busbar (PBB) in the main distribution frame (MDF). The PBB shall be bonded to the electrical ground bus bar (EGB) in the main electrical room with one (1) 4/0 AWG copper grounding conductor.
 2. Provide one (1) secondary bonding busbar (SBB) in each intermediate distribution frame (IDF). Each SBB shall be bonded to the PBB with one (1) 4/0 AWG copper grounding conductor.
 3. Provide ancillary bonding connections from each PBB and SBB to telecommunications equipment as detailed on the Contract Documents.
- C. Mechanical System Grounding:
 1. The incoming domestic and fire protection water services shall be bonded to the electrical grounding system; provide equipment grounding conductor (EGC) sized per the National Electrical Code.
 2. The incoming natural gas service shall be bonded to the electrical grounding system; provide equipment grounding conductor (EGC) sized per the National Electrical Code.
 3. All mechanical equipment, including but not limited to pumps, motors, packaged equipment, fans, heaters, etc. and their enclosures shall be properly grounded in accordance with Article 250 of the National Electrical Code.
 4. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- D. Separately Derived Systems: Ground and bond all separately derived systems in accordance with Article 250.30 of the National Electrical Code, and as follows:
 1. Transformers:
 - a. Provide a grounding electrode conductor from the transformer to the nearest grounding electrode, e.g. building steel. Where the grounding electrode conductor is installed within metallic raceway, both ends of the raceway shall be also be bonded.
 - b. Provide a system bonding jumper from the transformer neutral point to the transformer enclosure. The system bonding jumper must remain within the enclosure where it originates.

- c. Provide a supply-side bonding jumper from the transformer neutral point to the ground bus bar in the first disconnecting means or overcurrent device, e.g. panelboard.
 2. Generators:
 - a. Generators shall only be considered a separately derived system where the system grounded conductor (neutral) does not have a direct electrical connection to the building system.
 - b. Provide a grounding electrode conductor from the generator to the nearest grounding electrode.
 - c. Provide an equipment grounding conductor from the generator enclosure to the transfer switch enclosure.
 - d. Provide a system bonding jumper from the generator neutral point to the generator grounding point.
 - e. Refer to Division 26 Section 263213 “Engine Generators” for additional requirements.
 - f. Refer to Division 26 Section 263600 “Transfer Switches” for four-pole transfer switches used in separately derived systems.
 3. Metal Water Pipe:
 - a. All metal water piping in the area served by the separately derived system shall be bonded to the neutral point of the separately derived system with a bonding jumper in accordance with Article 250.104 of the National Electrical Code.
 - b. Metal water piping is permitted to be bonded to the structural metal building frame in lieu of the neutral point of the separately derived system, if the structural metal serves as the grounding electrode for the separately derived system.
 4. Structural Metal:
 - a. Exposed structural metal in the area served by the separately derived system shall be bonded to the neutral point of the separately derived system with a bonding jumper in accordance with Article 250.104 of the National Electrical Code.
 - b. A separate bonding jumper to structural metal is not required where the structural metal serves as the grounding electrode for the separately derived system.
 5. Grounding and bonding conductors and jumpers shall be sized in accordance with Table 250.66, Table 250.122 and Article 250.102 of the National Electrical Code.
- E. Metal Poles Supporting Outdoor Lighting Fixtures: Ground pole to a grounding electrode in addition to separate equipment grounding conductor run with supply branch circuit.

3.2. INSTALLATION

- A. General: Ground electrical systems and equipment according to NEC requirements, except where Drawings or Specifications exceed NEC requirements.

- B. Grounding Bus Bars: Space 1 inch (25 mm) from wall and support from wall 6 inches (150 mm) above finished floor, except as otherwise indicated.
- C. Grounding Electrodes: Provide a minimum of three (3) grounding electrodes, unless otherwise indicated on the Drawings, in accordance with the following:
 - 1. Locate a minimum of twenty-feet from each other and at least the same distance from any other grounding electrode, unless otherwise indicated on the Drawings.
 - 2. Drive until tops are 24 inches below finished floor or final grade, except as otherwise indicated.
 - 3. Interconnect with grounding-electrode conductors using exothermic welds, except at test wells, unless otherwise indicated. Make these connections without damaging copper coating or exposing steel.
- D. Grounding Conductors: Route along the shortest and straightest paths possible, except as otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- E. Underground Grounding Conductors: Use bare tinned copper wire. Bury at least 24 inches (600 mm) below grade.
- F. Metal Water Service Pipe: Provide insulated copper grounding conductors, sized as indicated, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding-clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Do not install a grounding jumper across dielectric fittings. Bond grounding-conductor conduit to conductor at each end.
- G. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding-clamp connectors.
- H. Test Wells: One for each driven grounding electrode, except as otherwise indicated. Set top of well flush with finished grade or floor. Fill with 1-inch- (25-mm-) maximum-size crushed stone or gravel.
- I. Grounding shall satisfy requirements of the applicable publications. All exposed noncurrent-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in nonmetallic raceways, and grounded conductors of the wiring system shall be grounded.
- J. 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.
- K. Ground buses and neutral buses in all switchboards, distribution panelboards, branch 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.

- L. 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.
- M. 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.
- N. 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.
- O. Grounding of exterior fence shall include ¾-inch x 8'-0-inch ground rods, ground clamps, flexible braided straps and other accessories as required for a complete ground system for fencing. Total resistance to ground shall not exceed 10 ohms.

3.3. CONNECTIONS

- A. General: Make connections so possibility of galvanic action or electrolysis 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.
 - 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
 - 4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
 - 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- B. Exothermic-Welded Connections: Use for connections to structural steel [and for underground connections, except those at test wells. Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
- C. Connections at Test Wells: Use compression-type connectors on conductors and make bolted- and clamped-type connections between conductors and grounding rods.
- D. Equipment Grounding Conductor (EGC) Terminations: For 8 AWG and larger, use compression-type grounding lugs. 10 AWG and smaller grounding conductors may be terminated with wire nut connectors as specified in Division 26 Section 260519, "Low-Voltage Electrical Power Conductors and Cables".
- E. 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.

- F. 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.
- G. 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.

3.4. UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

- A. Grounding System: Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes.

3.5. FIELD QUALITY CONTROL

- A. Independent Testing Agency: Engage an independent electrical testing organization to perform tests described below.
- B. Tests: Subject the completed grounding system to a megger test at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than 2 full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the 2-point method according to IEEE 81.
- C. Maximum grounding to resistance values are as follows:
 - 1. Equipment Rated 500 kVA and Less: 10 ohms.
 - 2. Equipment Rated 500 to 1000 kVA: 5 ohms.
 - 3. Equipment Rated More than 1000 kVA: 3 ohms.
 - 4. Manhole Grounds: 5 ohms.
- D. Excessive Ground Resistance: Where resistance to ground exceeds specified values, notify Owner promptly and include recommendations to reduce ground resistance and to accomplish recommended work.
- E. Report: Prepare test reports, certified by the testing organization, of ground resistance at each test location. Include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results. Submit all tests to the Architect for approval.

3.6. ADJUSTING AND CLEANING

- A. Restore surface features, including vegetation, at areas disturbed by work of this Section. Reestablish original grades, except as otherwise indicated. Where sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include top soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Maintain restored surfaces. Restore disturbed paving as indicated.

END OF SECTION

DIVISION 26 SECTION 26 05 28
FIRESTOPPING FOR ELECTRICAL SYSTEMS
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SECTION 26 05 28 – FIRESTOPPING FOR ELECTRICAL 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.
- B. Related Sections include the following:
 - 1. Division 26 Section 260533, “Raceways and Boxes for Electrical Systems”, for raceway seals and manufactured electrical devices.

1.2. SUMMARY

- A. Section includes:
 - 1. Through-penetration firestopping in fire rated construction.
 - 2. Through-penetration smoke-stopping in smoke partitions.

1.3. REFERENCES

- A. Underwriters Laboratories
 - 1. UL Fire Resistance Directory
 - a. Through-penetration firestop devices (XHCR)
 - b. Fire resistance rating (BXUV)
 - 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 detailed 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. Refer to Division 26 Section 260500, “Common Work Results for Electrical”, for sleeve requirements.

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.

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 penetrations 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 XHCR and XHEZ may be used, providing that it conforms to the construction type, penetrate 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 a 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. Fill, void or 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.
- D. Box Inserts: Intumescent inserts designed for installation inside of outlet and switch boxes to help protect fire-rated assemblies.
- E. Putty Pads: Moldable firestop putty designed for installation on outside of outlet and switch boxes.

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 barrier.
- C. Protect materials from damage on surfaces subject to traffic.
- 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 firestopping materials tested for the application.
- E. Install smoke stopping as specified for firestopping.
- F. Provide sleeves the full thickness of the assembly being penetrated and cut sleeves to a length of 1-inch more than the overall thickness of the penetration, or as recommended by the firestop manufacturer.
- G. Provide firestop box inserts and/or putty pads for outlet boxes in fire-rated partitions.

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. Perform under 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 2001	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+ CAJ2013 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 25 WB+ CAJ2090 FS-195+ 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	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
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 FS-195+
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+ CBJ8005 CS-195+, MPS-2+ CBJ8008 2001 FA8001 FS-195+, CP 25WB+	WL8002 CS-195+, FS-195+	

*Underwriter's Laboratories, Inc., Fire Resistance Directory.

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DIVISION 26 SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
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SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL 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.
- B. Related Sections include the following:
 - 1. Division 26 Section 260500, “Common Work Results for Electrical”, for general installation requirements.

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, concrete pads, 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. Product data 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. 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. 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.
 - 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. Dry, Interior Locations: 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 installed in dry interior locations shall be hot-dip galvanized, unless otherwise noted.
- B. Damp or Wet Locations: Supports, support hardware, and fasteners installed in damp or wet locations, including exterior locations, shall be Type 304 stainless steel.
- C. Kitchens & Foodservice Areas: Supports, support hardware, and fasteners installed in kitchens and other foodservice areas shall be 304 stainless steel.

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. U-Channel Systems:
 - 1. Sixteen-gauge channels with 9/16-inch-diameter slotted holes at a minimum of two inches on center in top surface.
 - 2. Provide fittings and accessories that mate and match with U-channel and are of the same manufacturer.
 - 3. Provide plastic end caps for ends of u-channel at free-standing equipment supports and exterior locations.
- 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.

2.5. VIBRATION ISOLATION MOUNT TYPES

- A. Type DNP (Double Neoprene Pad)
 - 1. Neoprene pad isolators shall be formed by two layers of ¼-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. Set Strut System components into final position true to line, level and plumb, in accordance with approved Shop Drawings.
- B. Anchor material firmly in place. Tighten all connections to their recommended torques.
- C. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.
- D. Coordinate with the building structural system and with other electrical installation.
- E. 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 until 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 1/4-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.
 8. In 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.
- F. 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.
- G. 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.
- H. 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 attachments to concrete slabs.
4. Concrete (New): Iron or steel inserts. Expander type anchors, specified for existing may be used provided concrete is clear of conduit for drilled depth.
 5. Concrete (Existing): Double-plated expander type anchors. Phillips, Hilti, or approved equivalent. Loads shall not exceed 1/4 of tested pullout (or shear) strength.
 6. Precast Concrete Plank: Drill hole through plank; bolt hanger rod to 4" x 4" x 1/8" steel plate on top of plank.
- I. 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.
- J. 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.
- K. 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 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
- L. Provide additional hangers or steel members to distribute the load among two or more structural members when required or directed.
- 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 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 1-1/2-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, splines, etc.).
5. In spaces with 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, "Interior 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" slip-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. Equipment shall not be held in place by its own dead weight. Provide base anchor fasteners in each case.
 14. 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.
 15. 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. TABLE I: SPACING FOR RACEWAY SUPPORTS

TABLE I: SPACING FOR RACEWAY SUPPORTS				
Raceway Size (Inches)	No. of Conductors in Run	Location	PVC & RMC (Ft.)	EMT (Ft.)
		HORIZONTAL RUNS		
3/4	1 or 2	Flat ceiling or wall.	5	5
3/4	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	7	7
3/4	3 or more	Any location.	7	7
3/4 - 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
Any	---	Concealed.	10	10

Abbreviations:	EMT	Electrical Metallic Tubing
	PVC	Rigid Polyvinyl Chloride Conduit
	RMC	Rigid Metal Conduit

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

DIVISION 26 SECTION 26 05 33
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
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SECTION 26 05 33 - RACEWAYS AND BOXES FOR ELECTRICAL 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.
- B. Related Sections include the following:
 - 1. Division 26 Section 260519, “Low-Voltage Electrical Power Conductors and Cables”, for conductors installed in raceways and boxes and conductor terminations.
 - 2. Division 26 Section 260528, “Firestopping for Electrical Systems”, for requirements for firestopping at penetrations through walls and floors that are fire barriers.
 - 3. Division 26 Section 260529, “Hangers and Supports for Electrical Systems”, for raceways and box supports.
 - 4. Division 26 Section 260535, “Raceways and Boxes for Low-Voltage Systems” for raceways and box requirements for communications cabling.
 - 5. Division 26 Section 260543, “Underground Ducts and Raceways for Electrical Systems” for raceways installed in ductbanks and for ductbank accessories.
 - 6. Division 26 Section 262726, “Wiring Devices”, for devices installed in boxes.

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. LFMC
 - d. PVC
 - e. PVC externally coated, RMC
 - f. RMC
 - g. RNC
 - h. Wireways
 - 2. Boxes, enclosures, and cabinets include the following:
 - a. Device boxes
 - b. Outlet boxes
 - c. Pull and junction boxes
 - d. Floor boxes
 - e. Audio/Video wall and/or ceiling boxes
 - f. Cabinets and hinged cover enclosures
 - 3. Miscellaneous Products include the following:

- a. Expansion/Deflection fittings
- b. Bushings

1.3. DEFINITIONS

- A. EMT: Electrical Metallic Tubing.
- B. FMC: Flexible Metal Conduit.
- C. LFMC: Liquid-tight Flexible Metal Conduit.
- D. PVC: Rigid Polyvinyl Chloride Conduit.
- E. RMC: Rigid Metal Conduit.
- F. RNC: Rigid Nonmetallic Conduit.

1.4. ACTION SUBMITTALS

- A. Product Data: For raceways, fittings, boxes, wireways, floor boxes, hinged cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5. INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Structural members in paths of conduit groups with common supports.
 - 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

1.6. 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 OSHA 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.

1.7. COORDINATION

- 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 final locations, mounting heights, and orientation of all outlet, junction, and pull boxes.
- E. Coordinate mounting heights and locations of outlet boxes thoroughly with approved Furniture plans.
- F. Coordinate floor box locations with Architect to ensure coordination with furniture arrangement.

1.8. 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. Triangle PWC, Inc.
 - l. Wheatland Tube Corporation
 - 2. Nonmetallic Conduit and Tubing:
 - a. Anamet, Inc.; Anaconda Metal Hose.

- b. Arnco 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 Corporation
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. 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. 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. Z/Gedney; Unit of General Signal.
 - k. Parker Electrical Manufacturing Co.
 - l. Robroy Industries, Inc.; Electrical Division.
 - m. Scott Fetzer Co.; Adalet PLM.
 - n. Spring City Electrical Manufacturing Co.
 - o. Thomas & Betts Corp.
 - p. Woodhead Industries, Inc.; Daniel Woodhead Co.

- 6. Floor Boxes:
 - a. American Electric
 - b. Carlon
 - c. Hubbell, Inc.; Wiring Devices Division
 - d. FSR, Inc.
 - e. Legrand/Wiremold
 - f. Square D Company

- 7. Audio/Video Wall Boxes:
 - a. FSR, Inc.
 - b. Hubbell, Inc.
 - c. Legrand/Wiremold

2.2. METAL CONDUITS AND FITTINGS

- A. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Metal Conduit:
 - 1. Colored EMT: Comply with ANSI C80.3 and UL 797; Hot galvanized steel O.D. with a vibrant color top coat and an organic corrosion-resistant I.D. coating.
 - a. Provide True Color® EMT as manufactured by Allied Tube and Conduit, or approved equal by listed manufacturer.
 - 2. EMT: Comply with ANSI C80.3 and UL 797; Hot galvanized steel O.D. with an organic corrosion-resistant I.D. coating.
 - 3. FMC: Comply with UL 1; zinc-coated steel.
 - 4. GRC: Comply with ANSI C80.1 and UL 6.
 - 5. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
 - 6. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
 - a. Comply with NEMA RN 1.
 - b. Coating Thickness: 0.040 inch (1 mm), minimum.
- C. Metal Fittings:
 - 1. Comply with NEMA FB 1 and UL 514B.
 - 2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 3. Fittings, General: Listed and labeled for type of conduit, location, and use.
 - 4. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
 - 5. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Compression.

6. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
 7. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
- D. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.3. NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

1. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

B. Nonmetallic Fittings:

1. Fittings, General: Listed and labeled for type of conduit, location, and use.
2. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
3. Solvents and Adhesives: As recommended by conduit manufacturer.

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:
1. Dry Interior Locations: Manufacturer's standard enamel or galvanized finish, NEMA 1.
 2. Damp/Wet Locations: ANSI 49 gray polyester over phosphatized steel, NEMA 3R.

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.

2.6. PULL AND JUNCTION BOXES

- A. Small Sheet Metal Boxes: NEMA OS 1, galvanized flat-rolled sheet steel.
- 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 raintight, galvanized cast iron box and cover with neoprene gasket and stainless-steel cover screws.
- D. Boxes for Buried Flush Grade Locations: Refer to Division 26 Section 260545, "Utility Holes", for product requirements.

2.7. BOX EXTENSIONS

- A. Where more than one box is needed to flush out installation, provide a large (i.e., 6" x 6") box to flush out the existing box and nipple over to a new box.

2.8. BUSHINGS

- A. Bushings shall be self-extinguishing thermoplastic type with 105 degrees C (minimum) temperature rating.
- B. Bushings with grounding lugs shall be malleable iron body with 105 degrees C (minimum) insulating ring. Insulating material shall be locked in place and non-removable.

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. 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.

2.11. SINGLE SERVICE FLOOR BOXES

- A. Description: Individual floor box for single service, e.g. power, microphone, telephone, data, CATV, etc., outlets as indicated on the Contract Drawings. For multiple floor devices, provide two-gang or three-gang box with dividers between compartments.
- B. General:
 - 1. Flush-mounted, rectangular boxes: 1, 2, or 3 gang.
 - 2. Carpet trim ring for devices in carpeted areas. Provide carpet insert.
 - 3. For tile, wood, or other hard floors, provide flush trim and coverplates, with no projections above the floor surface.
 - 4. Single or multi-gang coverplates as required.
- C. Construction:
 - 1. Non-metallic box.
 - 2. 1, 2, or 3 divided compartments – gangable
 - 3. Cut flush with concrete after pour.
 - 4. Brass or aluminum flange and cover with features as shown on the Drawings. Architect to select finish.
 - 5. UL listed for protection against scrub water.
- D. Receptacles, jacks and connectors: Provide receptacles, data, telephone, CATV and other connectors and wiring as indicated on the Drawings.
- E. Basis of Design: Provide 880MP/880MP2/880MP3 series floor boxes as manufactured by Legrand/Wiremold, or approved equal by listed manufacturer.

2.12. MULTI-SERVICE FLOOR BOXES

- A. Complete in-floor multi-service box consisting of floor box housing, flush removable cover, and wiring devices, as specified, all fittings, materials and labor.

- B. Make adjustments in leveling and placement during rough-in to accommodate structural and architectural elements, and other equipment. Coordinate exact locations with Owner prior to concrete pour.
- C. Construction:
 - 1. Formed steel with corrosion-resistant coating for on-grade applications and formed steel at all above grade levels unless otherwise noted on the Drawings.
 - 2. Galvanized steel per ASTM 525 G-60.
 - 3. Concrete-tight for in-floor use.
 - 4. Adjustable legs for leveling and adjustment prior to pour.
 - 5. Knockouts for conduit entry and feed-through use.
 - 6. Four (4), Six (6), or eight (8) wiring compartments as indicated on the contract drawings, individually sectionalized.
 - a. Two (2), Three (3), or Four (4) duplex 5-20R power receptacles as indicated on the contract drawings.
 - b. Two (2), Three (3), or Four (4) six-port low-voltage activation kits for technology/communications outlets as indicated on the contract drawings.
 - 7. UL listed, with separation of power and low voltage.
 - 8. Hinged, completely flush cover with cable ports. Cover shall be flanged. Finishes shall be selected by Architect from manufacturer's full range of options.
- D. Provide EFB Multi-Service recessed floor boxes as manufactured by Wiremold/Legrand, or approved equal.

2.13. FIRE-RATED MULTI-SERVICE POKE-THROUGH DEVICES

- A. Complete fire-rated multi-service poke-through device providing power, voice/data communications and A/V connectivity in an above grade concrete floor where power and communication devices are required. Poke-through devices enable flush device outlets for wiring and cabling in an open floor plan using core-drilled slab openings that will not obstruct the floor area.
- B. Specific codes and standards apply to electrical wires and telecommunication cables that are deployed within poke-throughs. Codes that are enforced by the local Authority Having Jurisdiction (AHJ) must be observed during construction.
- C. Make adjustments in placement during rough-in to accommodate structural and architectural elements, and other equipment. Coordinate exact locations with Owner prior to core-drilling concrete floors.
- D. Classification and Use: Poke-through devices shall have been examined and tested by UL to comply with UL514A and/or UL514C and bear the UL Listing Mark. Devices shall also have been tested by UL and classified for fire resistance and bear the UL Classification Mark. Devices shall be classified for use in 1, 1-1/2, or 2-hour rated floors, or concrete floors with suspended ceilings. Fire resistive designs with suspended ceilings shall have provisions for accessibility in the ceiling below the poke-through device fittings.
- E. Poke-through device assemblies shall consist of an insert and an activation cover, as

follows:

1. Insert: Insert body shall recess the devices a minimum of 2-3/4 inches (69mm) and have a polyester based backing enamel finished interior, ivory color. Furnish with necessary channels to provide complete separation of power and communication services.
 - a. Six-inch diameter devices shall provide three (3) compartments that allow for up to three (3) duplex receptacles and/or twelve (12) communication ports.
 - b. Eight-inch diameter devices shall provide five (5) compartments that allow for up to five (5) duplex receptacles and/or twenty-two (22) communication ports.
 2. Body shall consist of an intumescent firestop material to maintain fire rating of the floor slab. Intumescent material shall not have to be adjusted to maintain fire rating of the unit and the floor slab.
 3. Provide insert with a retaining feature to hold the poke-through device in the floor slab without additional fasteners.
 4. Poke-through insert shall also consist of a 3/4-inch trade size conduit stub that is connected to the insert body and a 24.5 cubic inch stamped steel junction box for wire splicing and connections. Stamped steel junction box shall also contain the means necessary to electrically ground the poke-through device to the system ground.
- F. Activation Covers: Manufactured of die-cast aluminum alloy, with powder coated finish available in gray, black, brass, nickel or bronze. Finish shall be selected by Architect; standard selections shall be provided at no additional cost. Provide covers with two (2) gaskets (one for surface and one for flush) to go under the trim flange to maintain scrub water tightness. Covers shall have spring-loaded sides to allow cables to egress out of the unit and maintain as small an egress opening as possible.
- G. Communication Modules and Mounting Accessories: Provide activation units with three locations to mount communication connectors. Mount connectors using a mounting bracket capable of accepting up to twelve (12) Ortronics TracJack Category 6 insert modules or TechChoice Category 6 discrete keystone connectors. Also provide units with two (2) Category 6 discrete keystone connectors and two (2) industry standard keystones and accommodate a mechanism to permit protection of communications cabling. Mechanism shall be fabricated from stamped steel and shall accept both flexible and rigid 3/4-inch, 1-1/4-inch, or 2-inch trade size conduit.
- H. Basis of Design: Provide 6AT and 8AT series poke-through assemblies as manufactured by Legrand/Wiremold, or approved equal by listed manufacturer.

2.14. AUDIO/VISUAL WALL BOXES

- A. Plated steel four-gang recessed wall boxes designed to provide wire and cable management support for A/V equipment. Provide upper and lower chambers with mounting plates for A/V cable jacks. Coordinate mounting plate requirements with Owner's A/V contractor. Upper chamber shall have 2" conduit knockout for A/V cabling.

- B. Coordinate details with Architect and Owner.
- C. Provide Legrand Wiremold Evolution Series Model EFSB4, or approved equal by FSR or Hubbell.

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 AND BOX REQUIREMENTS

- A. Conduit Application Schedule:

APPLICATION	CONDUIT TYPE	REMARKS
In or under concrete slab	RNC (Schedule 40 PVC)	Use RMC elbows to stub up through slab, unless otherwise noted on the drawings. Coat RMC with two heavy coats of asphaltum, or provide PVC-coated RMC.
Exposed exterior locations.	RMC	Use threaded or rain-tight fittings and stainless steel hardware.
Damp/Wet interior locations.	RMC	Use threaded or rain-tight fittings and stainless steel hardware.
Exposed dry interior locations.	EMT	Schedule 40 PVC is acceptable for concealing grounding electrode conductors, except for plenum spaces. Provide RMC conduit where subject to physical damage.
Exterior underground.	RNC (Sched. 40 PVC)	RMC Elbows/Sweeps unless otherwise noted on the Drawings. Coat RMC with two heavy coats of asphaltum, or provide PVC-coated RMC.
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 and stainless steel hardware.
Equipment connections in exterior locations.	LFMC (e.g Sealtite)	Short lengths only (maximum 6 feet). Use threaded or rain-tight fittings and stainless steel hardware.

APPLICATION	CONDUIT TYPE	REMARKS
Concealed in dry wall construction.	EMT, MC Cabling	Refer to Division 26 Section 260519, "Conductors and Cables", for MC Cable Requirements.
Concealed above suspended ceilings.	EMT, MC Cabling	Refer to Division 26 Section 260519, "Conductors and Cables", for MC Cable Requirements.
Concealed in masonry walls.	EMT	

B. General Requirements

1. Provide hot-dip Rigid Metal Conduit (RMC) for exposed work in locations subject to physical damage, and for work in damp/wet locations.
2. Conduits for exterior underground electric work shall be rigid steel, galvanized and sherardized, leaving the building and to points 5 feet beyond footings. Beyond 5 feet of building, underground conduits shall be non-metallic Schedule 40 PVC, Type II.
3. Elbows for conduits turning up through slabs and/or equipment pads shall be rigid metal conduit (RMC) unless otherwise noted on the Drawings or required by the electric utility.
4. All steel conduits below grade or in contact with earth shall be PVC-coated or painted with two heavy coats of asphaltum.
5. Conduits shall slope from entrance equipment toward outside of building.
6. Provide hot-dip Rigid Metal Conduit (RMC) with bonded PVC jacket (Plastic-Bond or Kor-Kap) for work not completely encased in concrete but laid directly in or in contact with ground or on a vapor barrier and additionally, as directed.
7. Provide hot-dip Rigid Metal Conduit (RMC) with bonded PVC jacket (Plastic-Bond or Kor-Kap) for work in kitchen coolers and freezers.
8. All emergency system wiring shall be installed in a dedicated conduit system clearly identified as "Emergency" or "Standby".
9. MC cable shall be permitted for emergency and standby system wiring where concealed above accessible ceilings and/or within drywall partitions in accordance with the requirements of this Section".

C. 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. Fasten EMT conduit with concrete-tight or rain-tight compression fittings made from zinc-plated steel. 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.
3. Fasten rigid metal conduit with threaded galvanized steel fittings, double locknuts, and insulated bushings. Insulated bushings shall be OZ/Gedney type "B", or equal.

4. Fasten Flexible Metallic Conduit (FMC) with Thomas & Betts (T&B) "Tite-Bite" insulated connectors, or equal.
5. 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.
6. Watertight fittings shall use a copper base anti-corrosive conductive compound. Provide watertight fittings for conduits in damp or wet locations, underground locations, and in floor slabs.
7. Provide UL listed compound filled 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.
8. 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 linear feet. The Contractor shall refer to the Architectural Drawings for expansion joint locations.

D. Conduit Bodies:

1. Conduit bodies shall be selected such that the conduit body access is parallel with the face of the adjacent box, enclosure, wall, etc.
2. LB conduit bodies shall be provided where the change in direction is to the back (e.g. through a wall).
3. LR conduit bodies shall be provided where the change in direction is to the left.
4. LL conduit bodies shall be provided where the change in direction is to the right.
5. C-Shaped conduit bodies shall be provided for straight runs with no change in direction.
6. T-Shaped and X-Shaped conduit bodies shall be provided where there are multiple changes in direction.

E. 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.

F. Outlet Boxes:

1. Outlet boxes for dry interior locations and 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 damp or wet locations shall be NEMA 4 cast-aluminum, cast steel or cast-iron type with gasketed cover plates and threaded hubs for conduit entrance.
3. Extra-large boxes shall be provided in accordance with the National Electrical Code where necessary to prevent crowding of wire in the box.

4. Plastic boxes and cast "white metal" boxes classified as NEMA 4 will not be acceptable.
5. Outlet boxes in un-plastered 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. Back-to-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. Outlet boxes in fire-rated partitions shall have firestop box inserts and/or firestopping putty pads. Refer to Division 26 Section 260528, "Firestopping for Electrical Systems", for additional information.
12. Provide factory-made knockout closures for unused openings in outlet boxes.
13. Provide blank coverplates for all unused boxes.
14. For multiple device installations, provide multi-gang boxes. Sectional boxes are not permitted. Provide barrier separation of different voltage conductors in the same box.
15. Thoroughly coordinate mounting heights of boxes with casework and backsplash heights.
16. 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.
17. Provide back supports for boxes in metal stud walls.

G. 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 conductors with different system voltages 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.

3.3. INSTALLATION OF RACEWAYS

- 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:
1. Communications System
 2. Control Wiring
 3. Emergency Lighting
 4. Emergency Power
 5. Fire Alarm System
 6. Incoming Telecommunications Service
 7. Incoming Electric Service
 8. Lighting
 9. Power 120/208 volt
 10. Power 277/480 volt
 11. Security System
 12. Standby Power
 13. Telephone Wiring
- C. All raceway systems shall be completely wired as specified herein, shown on drawings and/or required for satisfactory operation of the various systems.
- D. 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 in 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.
- E. Raceways or conduits entering buildings or structures from outside shall be sealed, including spare or unused raceways. Sealants shall be identified for use with the cable/conductor insulation.
- F. Raceways or conduits installed underground shall be sealed or plugged at both ends, including spare or unused raceways. Sealants shall be identified for use with the cable/conductor insulation.
- G. 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.
- H. Minimum Raceway Size:
1. 3/4-inch trade size for interior work
 2. 1-inch trade size for exterior underground work.
- I. Conceal raceways within finished walls, ceilings, and floors wherever possible, unless otherwise indicated.
- J. Electrical Metallic Tubing (EMT) shall be used for the following unless otherwise indicated:

1. Branch circuits and feeders for lighting, receptacles, and power concealed in:
 - a. Dry wall construction.
 - b. Hard ceilings, e.g. gypsum, wood, etc.
 - c. Masonry walls.
 2. Exposed in equipment room areas as needed to serve fixed equipment.
 3. Circuits for communication and signaling concealed in:
 - a. Dry wall construction.
 - b. Hard ceilings, e.g. gypsum, wood, plaster, etc...
- K. Rigid Metal Conduit (RMC) 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.
 2. Circuits for communication and signaling exposed in areas subject to physical damage.
- L. Communications, Control, Automatic Temperature Control (ATC), Fire Alarm, and Security system wiring shall be installed in raceways within partitions, terminated 8" above accessible ceiling with 90 degree bend with insulating bushing on the end. Free-run cabling above accessible ceilings shall be supported by J-hooks and/or bridle rings at required spacing intervals. Cabling above inaccessible ceilings and in exposed locations shall be installed completely in raceway.
- M. Wiring above ceiling shall be plenum rated cable, where required by Code.
- N. Wiring installed concealed above hard ceilings and exposed in areas with no ceilings shall be installed in conduit.
- O. Conduit shall be run concealed wherever possible, within walls, ceilings, or floors, unless otherwise indicated or specified. Where exposed conduits runs are shown or required, they shall be run parallel to building construction and shall be suitably supported at required intervals.
- P. 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.
- Q. 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.
- R. Install raceways level and square and at proper elevations. Provide adequate headroom.
- S. Complete raceway installation before starting conductor installation.
- T. Support raceways as specified in Division 26 Section 260529, "Hangers and Supports for Electrical Systems". Arrange supports to prevent misalignment during wiring installation.

- U. 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.
- V. 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.
- W. 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.
- X. 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.
- Y. Run concealed raceways, with a minimum of bends, in the shortest practical distance considering the type of building construction and obstructions, unless otherwise indicated.
- Z. Conduits may be installed in concrete floor slabs with the following limitations:
 - 1. Maximum size – 2”.
 - 2. Minimum concrete cover – 1", above and below.
 - 3. Minimum spacing between conduits - 6" on center.
 - 4. Conduit outside diameter - 1/3 of slab thickness, maximum.
 - 5. Installed between bottom and top reinforcing, and centerline of conduit at the mid-depth of the slab.
 - 6. Secured to prevent possible change in position, sagging, or shifting as concrete is poured.
 - 7. Water or damp-proofing integrity of slab is not disturbed.
 - 8. Conduits larger than 1-1/4" may be installed in [grade level] concrete floor slabs only with the specific permission of the Engineer, or as specifically indicated on the drawings, all in accordance with the above limitation.
 - 9. Conduits in close proximity to each other at panelboards, etc., shall be located and wrapped with wire mesh to prevent cracking of slab.
 - 10. Transition non-metallic tubing to rigid steel conduit before rising above the floor.
 - 11. Space raceways laterally to prevent voids in the concrete.
 - 12. Run conduit parallel to or at right angles to main reinforcement. When at right angles to reinforcement, place conduit close to slab support.
- AA. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
- BB. Run parallel or banked raceways together, on common supports where practical.
- CC. 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.
- DD. 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.
- EE. Tighten set screws of threadless fittings with suitable tools.
- FF. Install pull wires in empty raceways. Use 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.
- GG. Stub up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches (150 mm) above the floor. Install screwdriver operated, threaded flush plugs flush with floor for future equipment connections.
- HH. Lubricants for pulling wires shall be approved for use with the types of wire and conduit installed.
- II. PVC Externally Coated, Rigid Steel Conduits: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduits.
- JJ. Use conduit hubs to fasten conduit to boxes in damp and wet locations.
- KK. All metal raceways for circuits over 250-volts to ground shall be bonded per NEC Article 250.97.
- LL. 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 2 inches (50 mm) in size.
- MM. Avoid moisture traps; provide junction box with drain fittings at low points in conduit system.
- NN. Die-cast fittings of pot metal will not be accepted.
- OO. Conduits shall be free of any burrs, foreign objects, and water prior to conduit installation.
- PP. 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 3/4" conduit.
- QQ. 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.
- RR. Rigid conduit or Electrical Metallic Tubing (EMT) shall not be strapped or fastened to equipment subject to vibration or mounted on shock-absorbing bases.
- SS. Conduit shall be installed in such manner as to ensure against the collection of trapped condensation, and runs of conduit shall be without traps wherever possible. Drill 1/8"

diameter weep holes where necessary.

- TT. 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.
- UU. Provide wall flanges and gasketing on conduits entering fan housings to minimize air leakage at points of penetration of housing.
- VV. 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.
- WW. 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.
- XX. 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 conduits 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.
- YY. Screws and other hardware for all work in damp/wet locations shall be stainless steel, unless otherwise noted.
- ZZ. Zinc coated galvanized steel screws may be used for interior dry locations only.
- AAA. No running threads shall be cut or used.
- BBB. Conduits which are installed at this time and left empty for future use and which are five feet or more in length, including all telephone and communication conduits shall have a non-ferrous, 600 lb. tensile strength drag line left in place for future use. All empty conduits including conduit stubs shall be tagged at all exposed ends with tags identifying the location of the end of the conduit.
- CCC. In all instances where flush-mounted type panelboards are installed, provide spare (empty) conduits in accordance with schedule in Division 26 Section 262416, "Panelboards", Paragraph "Provision for Future Circuits at Flush-Mounted Panelboards". These conduits shall extend between the panelboard cabinet and a junction box located above accessible ceiling construction. This requirement also applies to surface-mounted and flush-mounted panelboards in spaces with inaccessible ceilings.

3.4. 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. Set floor boxes level and adjust to finished floor surface.
- C. 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.
- D. 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 zinc-coated galvanized steel screws. Paint interior and exterior surfaces with rust-inhibitive paint. (Pull boxes and covers shall be hot-dipped galvanized.)
- E. 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.
- F. Pull boxes shall be installed at all necessary points to facilitate pulling of wires and 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.
- G. 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.
- H. Pull boxes with barriers shall have a single cover plate and the barriers shall be of the same gauge as the pull box.
- I. Exposed pull boxes will not be permitted in finished spaces.
- J. Location of pull boxes shall be coordinated with piping, ductwork, and other equipment so as to permit sufficient clearance for maintenance and access.
- K. Pull boxes recessed in walls or partitions shall be provided with flanged type covers.
- L. Outlet boxes and covers shall be of proper Code size for the number of wires and/or conduits passing through or terminating therein, as well as the quantity, type, and dimensions of wiring device(s) installed therein. In no case shall any box be less than 4" square. Special attention shall be paid to boxes with deep wiring devices, E.G., GFCI receptacles, USB charger receptacles, and network lighting switches, etc.
- M. Outlet boxes for lighting fixtures shall be equipped with fixture supporting devices.
- N. Outlet boxes for switches shall be of the gang type.
- O. Each circuit in each pullbox shall be marked with a tag guide denoting panels to which they connect.
- P. Boxes shall be separated to prevent sound transmission. Back-to-back boxes shall not be used.
- Q. Outlet boxes shall be provided with suitable plaster rings and covers or plates.

- R. Unused knockout holes shall remain closed and those opened by error shall be closed with approved factory-made knock-out seals.
- 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 toggle 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.
- Y. Install hinged-cover enclosures and cabinets plumb. Support at each corner at minimum.

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 hub 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 enter a raceway, cabinet, pull box, and junction box, the conductors shall be protected by an insulated bushing providing a smoothly rounded surface.
- E. Water tight hubs 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. 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 as defined in Division 26 Section 260500, "Common Work Results

for Electrical”. 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.

3.7. PAINTING AND FINISHES

- A. All exterior equipment and conduits shall be painted to match adjacent surface in color as selected by Architect, unless otherwise indicated by the Architect.
- B. All exposed conduit, boxes, equipment, etc. shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.
- C. Conduit and boxes for fire alarm cabling and devices shall be red, except for finished locations, where they shall be painted to match adjacent surfaces.
- D. All exposed conduit, boxes, equipment, etc. on the stage/platform shall be painted flat black.
- E. Paint all steel conduits in contact with earth with two coats of asphaltum for corrosion protection.

3.8. 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.

3.9. 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.

END OF SECTION

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DIVISION 26 SECTION 26 05 35
RACEWAYS AND BOXES FOR LOW-VOLTAGE SYSTEMS
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SECTION 26 05 35 – RACEWAYS AND BOXES FOR LOW-VOLTAGE SYSTEMS

PART 1. GENERAL

1.1. RELATED DOCUMENTS

- A. Drawings and General Provisions of the contract, including general and Supplementary Conditions and Division 01 Specifications apply to this Section.

1.2. SUMMARY

- A. This section includes requirements for miscellaneous raceway systems for the following:
 - 1. Communications (data/voice) systems.
 - 2. Audio/Video systems.
 - 3. Security system.
 - 4. Access Control System.
 - 5. Video Surveillance System.

1.3. SCOPE OF WORK

- A. Provide conduit and boxes to form empty raceway systems.
- B. Equipment and wiring will be installed under Division 27 and Division 28 unless otherwise indicated on the Contract Drawings or in another Section of these Specifications.

PART 2. PRODUCTS

2.1. CONDUIT

- A. Minimum size 1" unless noted otherwise. Refer to Division 26 Section 260533, "Raceways and Boxes for Electrical Systems", for product requirements.

2.2. OUTLET BOXES

- A. General Requirements
 - 1. Provide single or multiple gang boxes as shown on the Contract Drawings.
 - 2. Outlet boxes shall be listed to UL Standard 514A, Metallic Outlet Boxes.
 - 3. Refer to Division 26 Section 260533, "Raceways and Boxes for Electrical Systems", for general product requirements.
- B. Two-Gang Outlet Boxes for Masonry Walls
 - 1. Description: Large capacity, two-gang, 4" deep outlet boxes with plaster/tile rings as required to suit device quantities and types. Boxes shall have welded corners and device ears inside the box to prevent mortar from getting in the device holes. Boxes shall accept standard device and flat covers. Boxes shall have a ground screw in each gang. Provide supports to secure outlet boxes to concrete block to prevent movement during construction.
 - 2. Dimensions: 4-1/4"H x 4"W x 4"D.

3. Capacity: 54 cubic inches.
 4. Knockouts:
 - a. Top: (2) 1/2", (2) 1/2"-3/4" tangential knockouts
 - b. Bottom: (1) 1" - 1-1/4" - 1-1/2" - 2" concentric knockouts
 - c. Back: (2) 1/2"-3/4" tangential knockouts
 5. Provide Hubbell Catalog No. HBL985, or approved equal by listed manufacturer.
- C. Three-Gang Outlet Boxes for Masonry Walls
1. Description: Large capacity, three-gang, 4" deep outlet boxes with plaster/tile rings as required to suit device quantities and types. Boxes shall have welded corners and device ears inside the box to prevent mortar from getting in the device holes. Boxes shall accept standard device and flat covers. Boxes shall have a ground screw in each gang. Provide supports to secure outlet boxes to concrete block to prevent movement during construction.
 2. Dimensions: 4-1/4"H x 5-7/8"W x 4"D.
 3. Capacity: 79 cubic inches.
 4. Knockouts:
 - a. Top: (3) 1/2", (3) 1/2"-3/4" tangential knockouts
 - b. Bottom: (1) 1/2", (1) 1/2"-3/4" tangential knockouts, (1) 1" - 1-1/4" - 1-1/2" - 2" concentric knockouts
 - c. Back: (3) 1/2"-3/4" tangential knockouts
 5. Provide Hubbell Catalog No. HBL986, or approved equal by listed manufacturer.
- D. Two-Gang Outlet Boxes for Metal Stud and GWB Walls
1. Description: Large capacity, two-gang outlet boxes with plaster/tile rings as required to suit device quantities and types. Boxes shall provide ample space for Category 6/6A and optical fiber cable bends. Boxes shall accept standard 4-11/16" mud rings.
 2. Dimensions: 4-11/16"H x 4-11/16"W x 3-1/4"D
 3. Capacity: 66.7 cubic inches.
 4. Knockouts
 - a. Sides: (2) 3/4"-1" tangential knockouts, (2) 1"-1-1/4" tangential knockouts, plus (2) 1"-2" concentric knockouts.
 - b. Back: (2) 3/4"-1" tangential knockouts, (2) 1/2" knockouts
 5. Provide Hubbell Catalog No. HBL260, or approved equal by listed manufacturer.
- E. Three-Gang Outlet Boxes for Metal Stud and GWB Walls
1. Description: Large capacity, three-gang outlet boxes with plaster/tile rings as required to suit device quantities and types. Boxes shall provide ample space for Category 6/6A and optical fiber cable bends. Boxes shall accept standard 4-11/16" mud rings.
 2. Dimensions: 4-11/16"H x 7-3/4"W x 3-1/4"D

3. Capacity: 113.3 cubic inches.
4. Knockouts:
 - a. Sides: (4) 1/2"-3/4" tangential knockouts, (4) 3/4"-1" tangential knockouts, (2) 1"-1-1/4" tangential knockouts, plus (2) 1"-2" concentric knockouts.
 - b. Back: (2) 1/2"-3/4" tangential knockouts, (2) 3/4"-1" tangential knockouts, (2) 1"-1-1/4" tangential knockouts
5. Provide Hubbell Catalog No. HBL263, or approved equal by listed manufacturer.

2.3. PULL AND JUNCTION BOXES

- A. Refer to Division 26 Section 260533, "Raceways and Boxes for Electrical Systems".

2.4. FLOOR BOXES

- A. Refer to Division 26 Section 260533, "Raceways and Boxes for Electrical Systems".

2.5. AUDIO/VIDEO WALL BOXES

- A. Refer to Division 26 Section 260533, "Raceways and Boxes for Electrical Systems".

2.6. COVER PLATES

- A. Device plates will be provided under Division 27 and Division 28.

PART 3. EXECUTION

3.1. INSTALLATION

- A. Provide all raceway components, as required, for complete system. Extend conduits and/or surface raceways to nearest accessible ceiling space for devices with connections within the space, and to the nearest accessible corridor ceiling space for connections/cabling back to the MDF or IDF room, unless otherwise noted on the drawings.
- B. Each run of conduit shall contain not more than two 90 degree bends and no run shall exceed 100 ft. in length. Minimum radii for bends: 10 1/2" for 1" conduit, and a minimum of ten times the trade size diameter bends for larger sizes. Do NOT use conduit fittings in lieu of bends.
- C. Provide insulating bushings on all conduit terminations.
- D. Provide pullboxes in conduit runs exceeding 100 feet (30 m) in length, and in runs with more than two right angle bends. Do NOT use conduit fittings in lieu of bends.
- E. Identify all cabinets, and pull and junction boxes as to system usage.
- F. Provide nylon pull cord in each conduit run.
- G. Provide identification tags on all conduit runs.

- H. Provide cover plates on all outlet boxes.
- I. Provide plywood backboards and duplex receptacles in equipment room(s). Confirm location on job site prior to installation. Paint all backboards with prime coat of fire resistant paint and finish coat of enamel in color to match wall. In unfinished rooms, provide gray finish coat.
- J. Coordinate all work with Owner and Division 27 and Division 28 Contractors.
- K. Provide underground conduit to property line for utility service entrance. Verify exact location with serving utility. Refer to Drawings and Division 26 Section 261120, “Utility Incoming Service Provisions” for additional information.

END OF SECTION

DIVISION 26 SECTION 26 05 43
UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS
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SECTION 26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1. RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications apply to this Section.
- B. Sections of other Divisions in this Specification which relate to excavation and concrete construction.
- C. Related Sections include the following:
 - 1. Division 26 Section 260519, “Low-Voltage Electrical Power Conductors and Cables”, for conductors installed in underground ducts and raceways.
 - 2. Division 26 Section 260528, “Firestopping for Electrical Systems”, for requirements for firestopping at penetrations through walls and floors that are fire barriers.
 - 3. Division 26 Section 260533, “Raceways and Boxes Electrical Systems”, for raceway requirements.
 - 4. Division 26 Section 260535, “Raceways and Boxes for Low-Voltage Systems”, for raceway requirements for communications cabling.
 - 5. Division 26 Section 260545, “Utility Holes”, for utility holes where underground ducts and raceways may terminate.
 - 6. Division 26 Section 260553, “Identification for Electrical Systems”, for underground line warning tapes to be installed above underground ducts and raceways.

1.2. SUMMARY

- A. This Section includes complete concrete ductbank construction and direct burial materials and methods for outside power and communications 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 facilities 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 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 ductbanks 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. Provide responsibility for coordinating and obtaining approvals of the location for temporary barricades and/or detours of traffic from the Police and Fire Departments.
 3. If peripheral fencing is used, it shall be provided with reflectors, flashers, signs, dangles, or barricades as the fence is being built.
 4. Maintain continued access to parking areas, roads, abutting properties, and other facilities which the construction will cross.
 5. If traffic is reduced to one way, provide a flag person. A minimum of one lane shall be maintained open to traffic at all times.

6. When entering or leaving road ways carrying public traffic, the equipment whether empty or loaded, shall in all cases yield to public traffic.
7. Supply and maintain cone placements at his sole additional expense.
8. All traffic signs which fall within the line of Construction or are obstructed by the equipment or operations shall be temporarily relocated to an unobstructed area. Temporarily relocated traffic signs shall be returned to their original location at the end of construction.

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, threaded type, coated with a polyvinyl chloride (PVC) sheath bonded to the galvanized exterior surface, nominal 40 mils thick, conforming to NEMA RN 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 strength in 28 days.
 - a. Cement: Portland Blast-Furnace Slag Cement, Type IS or equal meeting ASTM C593M 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.
 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.
 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 36 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 at 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: Rigid steel conduit with end bells shall be provided with an Appleton Catalog No. XJB Series or equal ground bushing with bonding strap. Connect bonding strap to ground wire in manhole(s) and electrical distribution equipment, e.g. transformer(s).
- I. Drainage Assembly: All ducts shall drain to an open end away from the building or electrical equipment. Ducts shall drain towards manhole(s) and handholes wherever possible.

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. Underground Line Warning Tapes:
1. Refer to Division 26 Section 260553, "Identification fore Electrical Systems", for product requirements.
 2. Bury underground line warning tape 12-inches below grade above every ductbank and buried conduit.

2.4. UNDERGROUND LINE WARNING TAPE

- A. Non-biodegradable, polyethylene tape, 5 mil minimum thickness and a minimum of 6 inches wide with detectable metallic foil. Provide warning labels on 3 foot centers, colored as follows:
1. Electrical ducts, piping or cable (600V and below) – Red tape with black printed labeling: CAUTION-BURIED ELECTRIC LINE BELOW.

2. Electrical ducts, piping or cable (above 600V) - Red tape with black printed labeling: CAUTION –BURIED HIGH VOLTAGE CABLE BELOW.
3. Telephone conduits or cable - Orange tape with black printed labeling: CAUTION –BURIED TELEPHONE LINE BELOW.
4. Communications Conduits or Cable – Orange tape with black printed labeling: CAUTION – BURIED COMMUNICATIONS LINE BELOW.
5. Fiber Optic conduits or cable - Orange tape with black printed labeling: CAUTION –BURIED FIBER OPTIC LINE BELOW.

2.5. 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 new work.
- B. Verify existing utilities, locations, and inverts and points of connection.

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 underground ductbanks for compliance with installation tolerances and other conditions affecting performance of the underground ductbanks. 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 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 risers) 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, leave no 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 tag.
- 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, vaults, 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 260500, “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 between utility holes and from utility holes to the building shall be completely excavated and graded before any duct is laid in that section.
- E. Provide underground line warning tape as specified herein 12-inches below finished grade over all ductbanks.
- F. Excavation and Backfill: Refer to Division 26 Section 260500, “Common Work Results for Electrical”.
- 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 utility holes or both ways from high points between utility holes for the required duct line drainage. Avoid pitching ducts towards buildings wherever 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 reestablish 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, cable 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. On completion of underground duct construction, replace pavements, sidewalks, curbs and gutters.
- O. 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 shall 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.
- C. Patching shall be done in accordance with the requirements of Division 02 for the appropriate disturbed surface materials.
- D. 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 building wall or utility hole penetration, install heavy wall galvanized steel conduit within the concrete envelope to provide protection against vertical shearing.
- B. 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

- 2. 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.
- C. Pitch conduit properly for drainage to manholes and handholes and to prevent low pockets or irregular dips between conduit ends. Minimum pitch to be 4 inches per 100 feet.
- D. Provide accurate locations of conduit in utility hole.
- 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 pull points for primary conduit and two 90-degree bends or equivalent for signal conduit.
- I. In ductbanks with both primary and signal conduit, primary conduit shall be straight and the signal conduit shall contain bends as necessary to accommodate the primary duct. Any offsets or bends shall be made in steel conduit. PVC conduit may only be used in straight lengths.
- J. Provide end bells on ducts at utility holes. When entering a manhole, end bells shall be a pre-manufactured system (system as manufactured by Formex or equal) with conduit seals and provisions for roughing into the concrete.
- K. Provide insulated, grounding bushings on duct ends in metallic equipment enclosure.
- L. Plug or cap empty conduits. Provide standard manufactured plugs.
- M. Seal all ducts and conduits, at both ends with foam duct sealant to prevent the entrance of moisture and gases. Refer to Division 26 Section 260500, "Common Work Results for Electrical" for product requirements.
- N. 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.
- O. Clear conduit by rod and pull an approved test mandrel from structure to structure or from structure to the conduit termination.

- P. Leave nylon or polyester pull line in each conduit, tagged to identify the conduit's point of origin, contents and final destination.
- Q. 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.
- R. 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.
- S. Install top of duct bank minimum 30 inches below finished grade.
- T. 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 conduits containing cables operating at not over 600 volts.
 - b. Two (2) inches between conduits containing cables operating at over 600 volts.
 - c. Two (2) inches between telecommunications conduits.
 - d. Six (6) inches between a telecommunications conduit and any power conduit in the same envelope.
 - 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 to 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 ductbanks, etc., shall be provided under this section of the work. All concrete shall be minimum 3,000 psi compressive strength at 28 days. Concrete for ductbanks shall be Class B, 470 lb. of Portland cement per cubic yard.
- B. Supervise the placement of concrete in the ductbank.
- C. Complete entire section of conduit from utility hole to manhole or from 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 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 on 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 ducts 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 encasements.
 - 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 clearances.
 6. Depth: Except as otherwise indicated, install top of duct banks at least 36 inches (900 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 utility holes 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. Stub-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 foam duct sealant as specified in Division 26 Section 260500, "Common Work Results for Electrical".
- Q. Duct Entrances to Manholes: Space end bells approximately 10 inches (250 mm) on center for 5-inch (125 mm) ducts and varied proportionately for other duct sizes. Change from regular spacing to end-bell spacing 10 feet (3m) from the end bell without reducing duct line slope and without forming a trap in the line. Grout end bells into manhole walls from both sides to provide watertight entrances. Provide expansion joint material between duct and handhole.
1. Duct bank envelopes connecting to underground structures shall be flared to have an enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 12 inches in each direction. Perimeter of the cut bank opening in the underground structure shall be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is placed to assure a seal between the envelope and the wall of the structure.
- R. Building Entrances: Transition from underground duct to conduit 10 feet (3m) 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

- 2. 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.
- S. 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 (2) 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 with a minimum radius of 36 inches for stub-ups at equipment and at building entrances. Use manufactured long sweep bends with a minimum radius of 25 feet 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 placing 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 at the time a 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 cleanup.

- H. Separation distance from other buried utilities as follows:
 - 1. All others: 18-inches.
- I. Cap ends of spare/empty ducts and raceways with manufactured end caps.
- J. Raceways or conduits entering buildings or structures from outside shall be sealed, including spare or unused raceways. Sealants shall be identified for use with the cable/conductor insulation.
- K. Raceways or conduits installed underground shall be sealed or plugged at both ends, including spare or unused raceways. Sealants shall be identified for use with the cable/conductor insulation.

3.8. DIRECT BURIED CONDUIT

- A. Provide where indicated direct-buried electrical circuits utilizing Schedule 40 PVC or PVC-coated rigid galvanized steel conduit, as indicated. Conduit shall be as specified in Division 26 Section 260533, "Raceways and Boxes for Electrical Systems". Burial depth shall be as follows:
 - 1. Below paved roads: 36-inches below bottom of paving.
 - 2. Under non-vehicle concrete: 36-inches below bottom of paving.
 - 3. Other areas: 30-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 expandable 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. IDENTIFICATION

- A. 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.

- B. Where two (2) or more services share a common ductbank, i.e. telephone and fiber optic, warning tape for each service shall be installed above each service's respective conduit(s).

3.10. 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, handholes 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.

3.11. 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.

END OF SECTION

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UTILITY HOLES
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SECTION 26 05 45 - UTILITY HOLES

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. Prefabricated and cast-in-place utility holes, utility hole accessories, and pre-cast polymer handholes.
- B. Complete construction and outfitting of all new utility holes, handholes, and in-ground junction boxes.
- C. Provide all labor, materials, equipment, and services necessary to provide utility holes and handholes as indicated on the Contract Drawings and as specified herein.
- D. Each utility hole shall include at least the following: cast iron cover and rim, masonry collar between the cast iron cover rim and the utility hole, drain field opening, drain field, grounding rod, support members for wire or cable, and ladder.
- E. The Contractor shall be responsible for the structural integrity of each utility hole as installed including its associated components such as: bearing capacity of the coil or fill supporting it, cast iron cover and rim, masonry collar, utility hole and openings through utility hole surfaces.

1.3. RELATED WORK

- A. Related Sections include the following:
 - 1. Division 26 Section 260500, “Common Work Results for Electrical”, for excavation and backfill requirements.
 - 2. Division 26 Section 260519, “Low-Voltage Electrical Power Conductors and Cables”, for conductors installed in raceways and boxes and conductor terminations.
 - 3. Division 26 Section 260543, “Underground Ducts and Raceways for Electrical Systems”, for direct-buried conduits and underground ductbanks terminating at utility holes.

1.4. QUALITY ASSURANCE

- A. Manufacturer Qualifications: Firm experienced in manufacturing underground precast concrete or cast-in-place utility structures of types and sizes required and similar to those indicated for this Project. Firm must have a minimum of a 3-year record of successful in-service performance.

- B. Comply with NFPA 70: National Electrical Code and ANSI C2 National Electrical Safety Code for components and installation.
- C. 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.
- D. Coordinate layout and installation of conduits, utility holes, and handholes with final arrangement of other utilities as determined in the field.
- E. Coordinate elevations of conduit and ductbank entrances into utility holes and handholes with final profiles of conduits as determined by coordination with other utilities and underground obstructions. Revise locations and elevations from those indicated as required to suit field conditions and ensure duct runs drain to utility holes and handholes, and as approved by the Engineer.
- F. The following Codes, Regulations, Reference Standards and Specifications apply to work included in this Section:
 - 1. Codes and regulations of the jurisdictional authorities.
 - 2. Codes and Standards, Section 01060:
 - a. AASHTO Standards: M199 - Precast Reinforced Concrete Utility Hole.
 - b. ANSI: C80.1.
 - c. ASTM: A36, A48, A153, A386, A615, C33, F512.
 - d. Federal Specifications:
 - i. TT-P-0035.
 - ii. RR-F-621E Frames, Covers, Gratings, Steps, Sumps, and Catch Basin Utility Hole.
 - iii. SS-S-210A, Sealing Compound, Pre-formed Plastic for Expansion Joints and Pipe Joints.
 - e. National Electrical Code, NFPA-70.
 - f. American Concrete Institute (ACI):
 - i. 318 - Building Code Requirements for Reinforced Concrete.

1.5. SUBMITTALS

- A. Submit shop drawings and product data under provisions of General Conditions of the Contract and Division 26.
- B. Indicate material specifications, dimensions, capacities, size and location of openings, reinforcing details, and accessory locations.
- C. Submit product data for utility holes, handholes, and accessories.
- D. Shop drawings showing details and design calculations for precast utility holes and

handholes, including reinforcing steel and required load-bearing capacity. Stamp drawings with seal of a Delaware registered professional structural engineer.

1. Drawings for each cast-in-place utility hole and handhole.
 2. Drawings for each size and configuration of precast utility hole and handhole with details of accessories and joints.
 3. Diagrams showing dimensioned locations for openings and knockout panels for duct penetrations of utility hole walls.
 4. Drawings depicting size, shape, configuration and identification of all cover plates and their legends.
- E. Submit site shop drawings indicating the proposed locations of all utility holes and handholes. Proposed deviations from the Contract Drawings shall be clearly marked on the Submittals. Shop drawings shall indicate duct profiles and coordination with other utilities and underground structures. Include plans and sections drawn to accurate scale.
- F. Submit manufacturer's installation instructions under provisions of General Conditions of the Contract.
- G. Certificate for concrete and steel used in underground precast concrete utility structures, according to ASTM C 858.
- H. Inspection report for factory inspections, according to ASTM C 1037.
- I. Field test reports indicating and interpreting test results relative to compliance with performance requirements of Field Quality Control Article in Part 3 of this Section.

1.6. PROJECT RECORD DOCUMENTS

- A. Submit under provisions Division 26 Section 260500, "Common Work Results for Electrical".
- B. Accurately record actual locations and depths of each utility hole and handhole. Indicate location, elevations, type of service, quantity and depth of all ductbank connections.

1.7. DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect, and handle products to site under provisions of Division 26 Section 260500, "Common Work Results for Electrical".
- B. Accept products on site. Inspect for damage.
- C. Deliver ducts to site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
- D. Store precast concrete units at site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

- E. Lift and support precast concrete units only at designated lifting or supporting points.

1.8. COORDINATION

- A. Obtain all available information on underground utilities before starting excavation. If underground utilities interfere with shown location of utility holes and/or handholes, bring this to the attention of the Engineer as soon as possible. The utility hole shall be revised or relocated only with the approval of the Engineer.
- B. Coordinate exact location of each utility hole and handhole centerline based on local grade, new and existing utilities, and other items which may affect placement.

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. Underground Precast Concrete Utility Structures:
 - a. A.C. Miller Products, Inc.
 - b. Easi Set.
 - c. Harford Concrete Products, Inc.
 - d. Riverton Concrete Products.
 - e. Rotondo/Penn-Cast, Inc.
 - f. Smith-Midland Corporation.
 - g. Utility Concrete Products.
 - h. Utility Vault Company.
 - 2. Frames and Covers:
 - a. Campbell Foundry Company.
 - b. East Jordan Iron Works, Inc.
 - c. McKinley Iron Works, Inc.
 - d. Neenah Foundry Company.
 - 3. Precast Polymer Handholes and Pullboxes:
 - a. APC Underground
 - b. Hubbell Quazite (Basis of Design)
 - c. Jensen Precast
 - d. Oldcastle
 - 4. Accessories:
 - a. Underground Devices, Inc.
 - b. Reef Industries, Inc.
 - c. Osborn Associates.
 - d. Carlon.

e. McGraw Edison.

2.2. GENERAL

- A. Portland Cement: Shall meet ASTM C-150, Type 1 specifications.
- B. Aggregate: Fine aggregate shall be sand, ASTM C-33. Coarse aggregate shall be well proportioned mixture conforming to size #4 and size #67, Table II, ASTM C-33.
- C. Water: Water shall be suitable for drinking.
- D. Mixture:
 - 1. Minimum cement content shall be 5-1/4 sacks per cubic yard. Maximum water shall be 6 gallons per sack. Ready-mix concrete shall meet ASTM C-94 specifications.
 - 2. Concrete shall have a minimum compressive strength of 3500# per square inch (24.2 mpa) in 28 days.
 - 3. Allowable slump shall not exceed 5 inches.
 - 4. Written approval of the Owner's Representative is required for job-mixed concrete.
 - 5. Concrete shall be of suitable consistency to completely fill forms and surround steel. Mechanical vibrations shall be used.
 - 6. Steel: AASHO H-20; bridge loading; new billet steel reinforcing bars.
 - 7. Reinforcing: AASHO H-20; bridge loading.
- E. Utility Hole Shape:
 - 1. Power utility holes shall be rectangular.
- F. Inside Dimensions:
 - 1. Power Utility Holes: Six ft (1.8 m) length; six ft (1.8 m) width; six ft six inches (1.98 m) high.
- G. Include a grooved opening in top section the same size as required for the necking, extension rings, and shaft openings listed below.
 - 1. Necking and Shaft Sections:
 - a. Power Utility Holes: 42 inch diameter clear opening.
- H. Include 18 inch (300 mm) drain opening and two (2) one-inch (25 mm) ground rod openings in base section.
- I. Waterproofing: Provide complete waterproofing top, bottom, and sides. Waterproofing to

be Tremco Tremproof 60 system or equal applied per manufacturer's recommendations.

- J. Utility holes shall be set on six inches (6-inch) minimum depth, of ¾-inch crushed rock or gravel bedding.
- K. Accessories: Utility Holes shall be supplied with all knockouts, inserts, risers, channels, pulling irons, and racking required for a complete installation.

2.3. PRECAST CONCRETE UTILITY HOLES

- A. Construction: Monolithic or in modular sections with gasketed tongue and groove joints. Complete with accessory items, hardware, and features as indicated. Include concrete knockout panels for conduit entrance and sleeve for ground rod.
- B. Wall Thickness: Not less than 6-inches.
- C. Provide a continuous water stop gasket at all section and slab joints.
- D. Design structure according to ASTM C 858.
- E. Structural Design Loading: ASTM C 857, Class A-16.
- F. Fabricate according to ASTM C 858.
- G. Joint Sealant: Continuous extrusion of asphaltic butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand the maximum hydrostatic pressures at the installation location with the ground water level at grade.
- H. Source Quality Control: Inspect structures according to ASTM C 1037.
- I. Reinforcing: Provide reinforcing which conforms to AASHTO H-20; Bridge Loading Specifications.
- J. In lieu of poured-in-place utility holes and handholes, the Contractor may provide AASHTO M 199 type precast units.
 - 1. Size: Plan area and clear height shall be not less than that shown on the Drawings for poured-in-place type.
 - 2. Accessories, hardware, and facilities shall be the same as required for poured-in-place type.
 - 3. Design: Design concrete mix and reinforcing placement in accordance with ACI 318. Design tops and walls of structures for AASHTO H-20 Bridge Loading, with 30 percent loading added for impact. Design walls to withstand all soil pressures. Take into consideration the soil encountered and ground water level present at the site. Assume ground water level three feet below ground surface unless a higher water table is shown in the boring logs and adjust design accordingly.
 - 4. Construction:

- a. Units, precast monolithically or of assembled sections.
- b. Assembled sections shall have mating edges with tongue and groove joints. Design joints to firmly interlock adjoining components, and provide waterproof junctions. Seal joints watertight using preformed plastic strip conforming to Federal Specification SS-S-210. Install sealing material in strict accordance with the sealant manufacturers' printed instructions.
- c. Provide lifting devices cast into units for proper handling of units.
- d. Identify all structures with manufacturer's name embedded in, or otherwise permanently attached to an interior wall face.
- e. Provide two (2) sleeves in utility hole floors so that a driven ground rod may be installed.

2.4. UTILITY HOLE ACCESSORIES

- A. Utility Hole Frames and Covers: Comply with Federal Specification RR-F-621 and ASTM A48: Class 30B; gray cast iron; machine finished with flat bearing surfaces. Size as required.
 1. All applications - heavy duty frames and covers:
 - a. Power Utility Holes: Neenah Foundry Catalog No. R-1792-JL, or approved equal.
 2. Utility hole lid lettering, with stamped letters not less than ½-inch high, as follows:
 - a. Power Utility Holes: ELECTRIC.
 3. Grounding hardware is to be cast bronze lug-mounted to the ring with a stainless steel 1/4-20 bolt threaded into the ring casting. Use #6 AWG copper ground conductor for connection to ground system or round rod.
 4. Provide a minimum of a one-foot thick by 48 inches in diameter pre-cast concrete collar between the utility hole and frame to elevate the cover to grade and for future adjustment.
- B. Pulling Irons:
 1. 7/8 inch (22 mm) diameter hot-dip galvanized steel reinforcement bar ASTM A615, Grade 60, welded, forming a triangle of 9 inches (225 mm) per side when set.
- C. Cable Rack Inserts: Continuous slot galvanized steel channel insert with minimum load rating of 2000 pounds (910 kg); 48 inch (1.2 m) length with rigid plastic closure strip or Styrofoam filler.
- D. Cable Clamps: Glazed porcelain insulators with channel clamp. Verify exact size needed in each case.
- E. Ground Rods: Provide two (2) per utility hole. All non-current-carrying metal parts including metallic sheaths of cables, shall be connected to the ground rod by a bare 2/0

AWG stranded soft drawn copper ground conductor. Install ground rod with top protruding four (4) inches above utility hole floor.

- F. Ground Wire: Provide 2/0 AWG bare stranded copper grounding conductor completely around each utility hole. Connect to ground rod.
- G. Sump Pit: 1' 6-inch diameter X 2' 0-inch long concrete pipe with sealed concrete bottom.
- H. Sump Pit Grate: Comply with Federal Specification RR-F-621 and ASTM A48: Class 30B, gray cast iron; light duty sized to fit sump pit concrete pipe above. Comply with FSRR-R-621, Type VII for frame and Type I for cover.
- I. Grounding: Provide as specified in Division 26 Section 260524, "Medium-Voltage Grounding" and elsewhere in these specifications.
- J. Coatings:
 - 1. Masonry Paint: FS TT-P-0035, waterproof, white.
 - a. Tnemec 66-1211 Epoxy Polyamide, or equal.
- K. Pulling Eyes in Walls: Hot dip galvanized steel eyebolt with reinforcing bar fastening insert. Two (2) inch (50mm) diameter eye, 1-inch (25 mm) by 4-inch (100 mm) bolt. Working load embedded in 6-inch (150 mm), 4000 psi (27.6 Mpa) concrete: 13,000 pounds minimum tension. Provide eyebolt for each wall. Locate near floor at the center of each wall.
- L. Pulling and Lifting Irons in Floor: Seven-eighth-inch-diameter (21 mm), hot-dipped galvanized, bent steel rod, stress-relieved after forming, and fastened to reinforced rod. Exposed triangular opening. Ultimate yield strength: 40,000 pounds shear and 60,000 pounds tension.
- M. Bolting Inserts for Cable Stanchions: Flared, threaded inserts of non-corrosive, chemical resistant, nonconductive thermoplastic material; 1/2-inch (12 mm) internal diameter by 2-3/4 inches (68 mm) deep, flared to 1-1/4 inch (30 mm) minimum at base. Tested ultimate pull-out strength: 12,000 pounds minimum.
- N. Expansion Anchors for Installation after Concrete is Cast: Zinc-plated carbon steel wedge type with stainless-steel expander clip 1/2-inch (12 mm) bolt size, 5300-pound rated pull-out strength, and 6800-pound rated shear strength minimum.
- O. Cable Stanchions: Non-metallic heavy duty 4-inch wide by 36-inch long size, punched with 9 holes on 4-inch centers for cable arm attachment. Provide on each of the four interior walls of each utility hole.
- P. Cable Arms: Three-sixteenth inch thick non-metallic heavy duty, approximately 67-inch wide by 14-inch long and arranged for secure mounting in horizontal position at any position on cable stanchions. Cable arms shall have a 350 lb. Load capacity with 3/8-inch deflection. Provide on each of the four interior walls of each utility hole.
 - 1. Insulators for cable supports: High glazed, wet process porcelain.

2. Spares: Equip each cable stanchion with two spare cable arms and six spare insulators for future use.
 3. Miscellaneous Hardware: Hot-dipped galvanized.
- Q. Duct Terminators: Plastic duct terminators with diaphragms. Sizes and locations shall be as required by ducts serving concrete structure.
- R. Duct Sealing Compound: Non-hardening, safe for human skin contact, not deleterious to cable insulation, workable at temperatures as low as 35 degrees F (1 degree C), withstands temperature of 300 degrees Fahrenheit (149 degrees C) without slump, and adheres to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and the common metals.
- S. Throat: Provide a precast concrete throat between the utility hole and frame. Seal outside of throat with waterproofing asphalt compound. Throats shall have concrete anchors formed in place for installation of galvanized steel step rungs. Rungs shall be spaced approximately 12-18-inch on center, with a step within 12-inch of top and bottom of collar.
- T. Ladder: Provide for each utility hole a hot dip galvanized steel ladder of sufficient height that reaches from the rim supporting the cover to the floor of the utility hole. Attachments to secure the removable ladder to the steel rim shall be stainless steel.

2.5. CONSTRUCTION MATERIALS

- A. Waterproofing:
1. Where openings are provided for the entrance of duct lines, the space between ducts and utility holes shall be filled with reinforced concrete and resultant gaps sealed with a watertight sealant to ensure watertight construction.
- B. Brick: Conform to ASTM C5, concrete brick Type I, Grande N.
- C. Mortar: Conform to ASTM C 270, Type M, except for quantities less than 2.0 cubic feet (60 L), where packaged mix complying with ASTM C 387, Type M may be used.

2.6. PRECAST POLYMER HANDHOLES AND PULL BOXES

- A. Description: Precast polymer concrete enclosures for use as hand holes, pull boxes, splice boxes or equipment enclosures for underground utility services.
- B. Construction:
1. Polymer concrete shall be made from selectively-graded aggregates in combination with a polymer resin, and shall be reinforced with fiberglass for exceptional strength and rigidity.
 2. Covers shall be heavy-duty type with gasket to reduce incoming fluids into the enclosure. Covers shall be secured to enclosures with stainless steel bolts.
- C. Dimensions:

1. Enclosures shall be sized as indicated on the Contract Drawings, unless otherwise noted or required by the National Electrical Code based on size and layout of conduits terminated at the same.
 2. Provide enclosures where required for long underground conduit runs, in addition to enclosures indicated on the Contract Drawings.
 3. Enclosures shall be no less than 11-inches x 18-inches x 18-inches deep.
- D. Covers:
1. Heavy-duty type with non-skid surface, same design load (Tier level) rating as respective enclosures.
 2. Tier level ratings shall be embossed on the surface of all covers.
 3. Gasket to reduce incoming fluids into the enclosure, secured to enclosures with stainless steel bolts.
 4. Factory embossed with lettering (minimum 1/2" high text) to identify system served by enclosure, as follows:
 - a. Power, 600V or Less: Electric
 - b. Lighting: Lighting
 - c. Grounding Electrode: Ground
 - d. Telecommunications: Communications
 - e. Telephone: Telephone
 - f. Cable Television: C.A.T.V.
 - g. Optical Fiber: Fiber Optics
- E. Installation: Enclosures shall sit flush with finished grade elevation. Provide a minimum of 6-inch layer of compacted gravel for drainage, with filter cloth between handhole and gravel layer.
- F. Quality Assurance:
1. Enclosures and covers shall conform to all test provisions of the most current ANSI/SCTE 77 "Specification for Underground Enclosure Integrity" for Tier 15 (minimum) applications and shall be UL listed. Refer to Contract Drawings for Tier Ratings of individual handholes.
 2. Independent third party verification or test reports stamped by a registered Professional Engineer certifying that all test provisions of this specification have been met shall be included with product submittal.
- G. Basis of Design: Quazite PG style enclosures, as manufactured by Hubbell.

PART 3 EXECUTION

3.1. EXCAVATION

- A. Provide responsibility for all demolition, excavation and backfilling required to install utility holes and handholes.
- B. After completion of utility hole installation, return all ground and pavement surfaces to original condition or to condition as indicated on the drawings. This includes all sidewalks, curbs, streets, parking areas, lawns, shrubs, etc.

3.2. INSTALLATION – PRECAST CONCRETE UTILITY HOLES

- A. Install and seal precast sections in accordance with manufacturer's instructions.
- B. Use gasketed precast neck and shaft sections to bring utility hole entrance to proper elevation.
- C. Install utility holes plumb.
- D. Set the top of each utility hole to finished grade elevation.

3.3. INSTALLATION – UTILITY HOLE ACCESSORIES

- A. Insert and seal sump pit into utility hole floor. Put one sump pit in each utility hole except, where a power and a communications utility hole are side-by-side, place one sump pit in the communications utility hole and core a 4-inch hole at the floor line from the electric utility hole to the communications utility hole.
- B. Grounding: Install ground rod(s) with top protruding 4 inches (100 mm) above utility hole floor.
- C. Ground Wires:
 - 1. Install the ground wires around the inside perimeter of the utility hole(s) and anchor them to the walls.
 - 2. Connect the ground wires to the ground rod by exothermic welding process to form solid metal joints.
 - 3. Bond the ground wires to any splice shield wires, ground wires, cable racks, utility hole frames, sump frames and other metal items in the utility hole.
 - 4. All separate ground wires accompanying circuits shall be grounded in each utility hole passed through.
 - 5. Utility Holes: Install a driven grounding rod close to wall and set rod depth so 4 inches (100 mm) will extend above finished floor. Where necessary, install grounding rod before utility hole is placed and provide a 2/0 AWG bare, tinned-copper conductor from grounding rod into utility hole through a waterproof sleeve in utility hole wall. Protect grounding rods passing through concrete floor with a

double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve form 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.

6. Connections to Utility Hole Components: Connect exposed metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each utility hole or hand hole, to grounding rod or grounding conductor. Make connections with minimum 2 AWG stranded, hard-drawn copper wire. Train conductors plumb or level around corners and fasten to utility walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

D. Cable Support System:

1. In each utility hole, after utility hole installation is complete, install porcelain cable clamps on all of the walls for not less than one set of cables, and as many additional racks as required for the cables which are being installed for this contract.
2. Cable support intervals shall be approximately 36 inches. Install racks at the above spacing on all walls for not less than one cable, whether or not the racks will be used for cables. Install additional racks as required for the cables. Each rack shall include porcelain cable support insulators.
3. Provide adequate slack in the cables.
4. Strap cable to insulators with plastic tie wraps.
5. All phase and ground cables in each circuit shall be kept together and contained on/in the porcelain cable supports. No phase cable shall be run separate from the other two phases and ground.
6. Waterproof exterior surfaces, joints, and interruptions of utility holes.
7. Install cable pulling irons opposite each duct entry window.

3.4. INSTALLATION – HANDHOLES AND PULLBOXES

- A. Install precast handholes and pullboxes in accordance with manufacturer's instructions.
- B. Use gasketed precast neck and shaft sections to bring utility hole entrance to proper elevation.
- C. Install utility holes plumb.
- D. Set the top of each utility hole to finished grade elevation.
- E. Provide where indicated and where required for long underground wire runs. Larger dimensions may be required per NEC for cables involved.
- F. Handholes shall be set level and adjusted for the final grade. Conduit penetrations shall be sealed with grout or waterproof sealant. All conduit ends shall have nylon or plastic bushings to prevent damage to insulation when pulling.

- G. All wiring within handholes, whether spliced or not, shall be identified with permanently indented or engraved tags as to circuit origination, circuit #, and load served.
- H. Cap ends of spare/empty conduits stubbed up in handholes with manufactured end caps.
- I. Seal ends of conduits with conductors in handholes with foam duct sealant as specified under Division 26 Section 260500, “Common Work Results for Electrical”.

3.5. UNDERGROUND UTILITY STRUCTURE INSTALLATION

- A. Elevation: Install handholes with depth as indicated. Where indicated, cast handhole cover frame directly into roof of handhole and set roof surface 1-inch (25 mm) above grade.
- B. Drainage: Install drain in bottom of each unit. Arrange to coordinate with drainage provisions specified.
 - 1. Eighteen-inch bell end, twenty-four-inch long concrete pipe through sump at the bottom of the utility hole with grated cover plates.
 - 2. Two cubic feet gravel-filled sump.
- C. Provide drainage facilities for utility holes where possible.
- D. Place reinforcing in accordance with shop drawings.
- E. Provide for location of duct entrances and inserts in walls.
- F. Place concrete as specified in Division 03.
- G. Install conduits of material shown.
- H. Install end bells on conduits where ducts terminate in utility holes and handholes.
- I. Cap ends of spare/empty conduits with manufactured end caps.
- J. Seal ends of conduits with conductors with foam duct sealant as specified under Division 26 Section 260500, “Common Work Results for Electrical”.
- K. Build duct formation into walls of utility holes and seal around opening.
- L. If location of utility hole and/or handhole openings will be obstructed, inform the Owner immediately.
- M. Install frame and cover, adjust to finished grade.
- N. Seal conduit openings with approved conduit plugs.
- O. Install cable pulling eyes and steps.
- P. Install ground rods as per NEC.
- Q. When installing sections of precast handholes, prevent damage to joint seals.

- R. Provide full-height channel inserts approximately 2 feet on center along interior walls, spaced to clear duct entrances and steps. Provide pull-out test information from the manufacturer and/or calculations from a professional engineer registered in the State of Delaware.
- S. Paint interior of utility hole(s), except floor, with two (2) coats of masonry paint, 10 mils minimum total dry film thickness.
- T. Access: Install cast-iron frames and covers. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney. Set frames in paved areas and traffic ways flush with finished grade. Set other frames 1-inch (925 mm) above finished grade.
- U. Waterproofing: Apply waterproofing to exterior surfaces of units. After ducts have been connected and grouted, and prior to back filling, waterproof joints and connections and touch up abrasions and scars.
- V. Hardware: Provide removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cable and conductors and as indicated. For each utility hole/handhole, provide one (1) stanchion for each thirty (30) linear inches (750 mm) of interior floor perimeter. In addition, provide one (1) arm for each stanchion, three (3) insulators for each arm, and a total of three (3) pulling eyes.
- W. Field-Installed Bolting Anchors: Do not drill deeper than 3-7/8 inches (96 mm) for anchor bolts installed in the field. Use a minimum of two (2) anchors for each cable stanchion.
- X. Grounding: Install ground rod through floor in each structure with top protruding four (4) inches (100 mm) above floor. Seal the floor opening against water penetration with waterproof non-shrink grout. Ground exposed metal components and hardware with bare copper ground conductor. Train conductors neatly around corners. Install on walls and roof using cable clamps secured with expansion anchors. Bond all reinforcing steel with common bonding ribbon or cable. Extend bonding cable into utility hole (and handhole) and connect to grounding system. Connect all metal surfaces using approved grounding fitting and connectors to a 2 AWG solid copper bare wire and provide an exothermic weld to the ground rod.
- Y. Precast Concrete Underground Structure Installation: Install as indicated, according to manufacturer's written instructions and ASTM C 891.
 - 1. Install units plumb and level and with orientation and depth coordinated with arrangement of connecting ducts to minimize bends and deflections required for proper entrances.
 - 2. Support units on a level bed of crushed stone or gravel, graded from the 1-inch (25 mm) sieve to the No. 4 sieve and compacted to the same density as the adjacent undisturbed earth.

3.6. FIELD QUALITY CONTROL

- A. Testing: Demonstrate capability and compliance with requirements upon completion of installation of underground duct and utility structures.

1. Grounding: Test utility holes grounding to ensure electrical continuity of bonding and rounding connections. Measure ground resistance at each ground rod and report results. Use an instrument specifically designed for ground-resistance measurements.
 2. Duct Integrity: Rod ducts with a mandrel 1/4-inch (6 mm) smaller in diameter than internal diameter of ducts. Where rodding indicates obstructions in ducts, remove the obstructions and retest.
 3. Water Tightness: Make internal inspection of utility holes and handholes three (3) months after completion of construction for indications of water ingress. Where leakage is noted, remove water and seal leak sources. Reinspect after two (2) months and reseal remaining leak sources. Repeat process at two (2) month intervals until leaks are corrected.
- B. Correct installations where possible, and retest to demonstrate compliance. Otherwise, remove and replace defective products and retest.

3.7. CLEANING

- A. Pull brush through full length of ducts. Use round bristle brush with a diameter 1/2 inch (12 mm) greater than internal diameter of duct.
- B. Clean internal surfaces of utility holes and handholes, including sump. Remove foreign material.
- C. All necessary precautions to avoid the flooding of utility holes and conduits. If the utility holes or conduits should become flooded or littered with debris any time prior to final acceptance, pump dry and clean utility holes and ducts to the satisfaction of the Engineer.
- D. Clean-Up: Remove debris from handholes and ensure complete installation is left in neat and finished condition.

END OF SECTION

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DIVISION 26 SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS
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SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL 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.
- B. Related Sections include the following:
 - 1. Division 26 Section 260543, “Underground Ducts and Raceways for Electrical Systems”, for underground line warning tape.
 - 2. Division 26 Section 260573, “Power System Studies”, for arc-flash hazard labels for electrical equipment.
 - 3. Division 26 Section 262416, “Panelboards”, for circuit directories to be installed in panelboards, including circuit directories.
 - 4. Division 26 Section 262726, “Wiring Devices”, for factory-engraved device plates.

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, 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.

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 as well as circuit designation for all feeders.
 - 3. Emergency circuits shall also have legend to read “EMERGENCY”.
- B. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl with legend, overlaminated with a clear, weather- and chemical-resistant coating.
- C. Pretensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color-coded, 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 3 mils thick by 3/4 inch 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. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

2.2. WIRING DEVICE FACEPLATE LABELS

- A. Adhesive Labels:
 - 1. Thermal transfer printable, clear polyester material with glossy finish, 1/2" high, width as required. Printed lettering shall be 1/4" high black text.
 - 2. Labels shall be backed with permanent acrylic adhesive and shall exhibit good adhesion to many metal and other types of surfaces, including textured surfaces and low surface energy plastics.
 - 3. Labels shall be resistant to humidity, temperature and UV light.
 - 4. Labels shall meet requirements of UL 969 Labeling and Marking Standard and shall be RoHS compliant.
 - 5. Provide Brady B-432 Series, or approved equal by acceptable manufacturer.
- B. Factory Labeled Faceplates:
 - 1. Faceplates for devices on emergency circuits shall be factory-engraved to read “EMERGENCY”. Refer to Division 26 Section 262726, “Wiring Devices”, for additional information.
 - 2. Faceplates for devices on GFCI-protected circuits shall be factory engraved to read “GFCI”. Refer to Division 26 Section 262726, “Wiring Devices”, for additional

information.

2.3. EQUIPMENT NAMEPLATES

A. General Nameplate Requirements:

1. Use colors prescribed by ANSI A13.1, NFPA 70 and as follows:
 - a. Normal Power System: White lettering on black background.
 - b. Emergency Power System: White lettering on red background, unless otherwise required by the Authority Having Jurisdiction (AHJ).
 - c. Standby Power System: White lettering on purple background, unless otherwise required by the Authority Having Jurisdiction (AHJ).
2. Backed with adhesive material formulated for the type of surface, intended use and installed location.

B. Nameplates for Dry, Interior Locations:

1. Engraving stock, melamine 3-layer plastic laminate.
2. Minimum 1/16-inch (1.6-mm) thick for signs up to 20 sq. inches (129 sq. cm)
3. Minimum 1/8-inch (3.2-mm) thick for signs larger than 20 sq. inches.

C. Nameplates for Damp/Wet Interior and Exterior Locations:

1. Weather-resistant, UV Resistant, minimum 1/8-inch (3.2-mm) thick.

D. Refer to Contract Drawings for typical nameplate details.

E. Refer to Paragraph "Equipment Identification Nameplates" under Part 3 of this Section for installation requirements.

2.4. SAFETY SIGNS

A. Comply with 29 CFR, Chapter XVII, Part 1910.45.

2.5. 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 185 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: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

PART 3. EXECUTION

3.1. INSTALLATION

A. General:

1. Where mixed voltages are used in one building (e.g., 480 volts, 208 volts), each piece of equipment, including but not limited to, switchboard(s), panelboard(s), transformer(s), enclosed switches, outlet/pull/junction boxes, 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 source switchboard or distribution panelboard serving the same.
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 wiring device faceplates and electrical equipment shall be installed plumb and neatly on all equipment.
6. Install nameplates/labels parallel to equipment lines.
7. Install nameplates/labels on equipment fronts/covers unless otherwise noted.
8. Install nameplates/labels on inside face of equipment door/cover, including junction boxes, where exposed in finished spaces.
9. Secure nameplates to inside of recessed panelboards in finished locations.
10. Embossed tape will not be permitted for any application.
11. Stenciling is prohibited.
12. Labels: All labels shall be permanent and be machine-generated. NO HANDWRITTEN OR NON-PERMANENT LABELS SHALL BE ALLOWED.
13. Label size shall be appropriate for the conductor/cable size(s), and wiring device faceplate layout. All labels to be used shall be self-laminating, white/transparent vinyl and be wrapped around the conductor/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. Miscellaneous Identification:

1. Individual circuit breakers and switches, in distribution panelboards and switchboards: 1/4-inch (6 mm) text; identify circuit and load served, including location.
2. Individual circuit breakers, enclosed switches, and motor starters: 1/2-inch (13mm) and 1/4-inch (6 mm) text; identify load served, circuit and voltage.
3. Junction boxes: 1/4-inch (6 mm) text; identify load served, circuit and voltage.

C. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

D. 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.

- E. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.
- F. Self-Adhesive Identification Products: Clean surfaces before applying.
- G. Caution Labels for Boxes and Enclosures: Provide pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background.
- H. Circuit Identification Labels on Boxes:
 - 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.
- I. Secondary Service, Feeder, and Branch-Circuit Conductors: Color-code throughout the secondary electrical system. Refer to Division 26 Section 260519, “Low-Voltage Electrical Power Conductors and Cables”, for additional requirements.
- J. Power-Circuit and Control Wire Identification: For each conductor, cable, feeder, and power circuit in transformers, switchboards, panelboard gutters, outlet boxes, junction boxes, pull boxes, and at load connections. Identify 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. Self-Adhesive Labels
 - a. Legend: 1/4-inch letter and number, typewritten
 - 2. Metal Tags or Aluminum Wraparound Marker Bands
 - a. Legend: 1/4-inch- (6.4-mm-) steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
 - b. Tag Fasteners: Nylon cable ties.
 - c. Band Fasteners: Integral ears.
- K. 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.
- L. 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.

M. Equipment Nameplates

1. 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.
2. Install on each piece of equipment provided with factory installed disconnecting means, e.g. ERV units, where a separate external disconnecting means is not provided under Division 26.
3. Install on each variable frequency drive serving pumps, fans, etc. provided by others where a separate motor controller is not provided under Division 26.
4. Unless otherwise noted, nameplates shall identify equipment designation(s), voltage rating, and source (including source locations).
5. Nameplates for disconnect switches, motor starters, etc..., shall indicate the designation of the load served as the “equipment designation”.
6. In general, nameplates 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 ½ 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 nameplate examples.
7. Apply nameplates to each unit of the following categories of equipment:
 - a. Switchboards
 - b. Transformers
 - c. Panelboards
 - d. Disconnect Switches
 - e. Enclosed Circuit Breakers
 - f. Enclosed Contactors
 - g. Motor Controllers
 - h. Generators
 - i. Transfer Switches
 - j. Electrical Cabinets and Enclosures
 - k. Lighting Control Panels
 - l. Fire Alarm Control Panel
 - m. Access Doors and Panels for Concealed Electrical Items.

N. 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 circuit designation followed by feeder voltage.
- O. Fire Alarm: Junction box covers shall be painted red, except in finished spaces where they shall be painted to match adjacent surfaces. Box covers shall have a type written label to read “Fire Alarm” in accordance with requirements of NFPA 72.
 - P. Provide NEC, ANSI, and OSHA-approved DANGER - HIGH VOLTAGE warning signs 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.
 - Q. Surfaces shall be cleaned and painted, if specified, before applying markings.
 - R. Place markings so that they are visible from the floor.
 - S. Protect finished identification to ensure that markings are clear and legible when project is turned over to the Owner.

END OF SECTION

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POWER SYSTEM STUDIES
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SECTION 26 05 73 – POWER SYSTEM STUDIES

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. Power system studies shall be performed on and include all portions of the electrical distribution system. The power system studies shall include the following:
 - 1. Short-circuit analysis with protective device evaluation
 - 2. Protective device time-current coordination analysis
 - 3. Arc flash hazard analysis
- B. The power system studies shall begin at the overcurrent protective device ahead of the new pad-mounted medium-voltage transformer, to the 480Y/277V main switchboard (MSB) and continue through the 480Y/277V and 208Y/120V distribution systems to the branch panelboards, including dry-type transformers.
- C. The power system studies shall also include the on-site emergency/standby power supply system, including the on-site generator, transfer switch(es), and associated electrical distribution equipment.
- D. The short-circuit analysis shall, at a minimum, include determining the available fault current at the following equipment:
 - 1. Service equipment in accordance with NEC Article 110.16(B).
 - 2. Switchboards and panelboards in accordance with NEC Article 408.6.
 - 3. Air-conditioning and refrigeration equipment in accordance with NEC Article 440.10.
 - 4. Elevator control panels in accordance with NEC Article 620.
- E. The arc flash hazard analysis shall be per the requirements set forth in the current version of NFPA 70E – Standard for Electrical Safety in the Workplace, and shall be performed according to the latest edition of IEEE Standard 1584, the IEEE Guide for Performing Arc-Flash Calculations.

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 one of the following, or an approved and qualified equal.
 1. AB Engineering, LLC
303 Dressage Court
West Chester, PA 19382
Telephone: 610-765-1290
Fax: 610-785-1319
Contact: Alton Baum, P.E.
 2. Cable Testing Services, Inc.
505 School House Road
Kennett Square, PA 19348
Telephone: 302-369-5420
Fax: 302-369-5515
Contact: Chris Fultz
 3. Coordinated Power Engineering, Inc.
1340-G Charwood Road
Hanover, MD 21076
Telephone: 410-694-9494

- Fax: 410-694-0085
Contact: Carl E. Rager, P.E.
4. IETC
5410 Mt. Pigsah Road
York, PA 17406
Telephone: 717-252-4730
Fax: 717-252-4793
Contact: William N. Luddy, P.E.
5. Keystone Engineering Group, Inc.
590 East Lancaster Avenue, Suite 200
Frazer, PA 19355
Telephone: 610-407-4100
Fax: 610-407-4101
Contact: Philip M. Gonski, P.E.
6. Potomac Testing, Inc.
1610 Professional Blvd, Suite A
Crofton, MD 21114
Telephone: 301-352-1930
Toll-Free: 1-800-331-2022
Contact: Paul Gill, P.E.
7. Reuter Hanney
11620 Crossroads Circle, Suite D-E
Middle River, MD 21220
Telephone: 410-344-0300
Fax: 410-335-4389
8. Schneider Electric
9 East Court, Suite G
Owings Mills, MD 21117
Telephone: 410-559-2917
Contact: Larry Long

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 a list of 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 contribution 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 section 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 centers, 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, tap, 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 melting current, 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 devices, 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, tabular 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, 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 enclosed 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 check 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 maximum clearing time of 2 seconds will be used based on IEEE 1584, 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.
4. The Arc-Flash Hazard Analysis shall also include copies of arc-flash hazard warning labels specified in Part 3 of this Section, for all pieces of equipment receiving a label, which shall also be included in the O&M Manual specified in Division 01.

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 HAZARD LABELS

- A. Contractor shall provide a 4.0 in. x 4.0 in. (nominal) 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. Equipment Designation
 2. Source Designation
 3. Fault Current (kA)
 4. System Voltage
 5. Flash Protection boundary
 6. Personal Protective Equipment category

7. Arc Flash Incident energy value (cal/cm²)
 8. Limited and restricted Approach Boundaries
 9. Study report number and issue date
 10. Name of Company who completed study
- 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 or 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. AVAILABLE FAULT CURRENT LABELS

- A. Contractor shall provide a 4.0 in. x 4.0 in. Brady thermal transfer type label of high adhesion polyester to identify the maximum available fault current at the following equipment:
1. Service equipment in accordance with NEC Article 110.16(B).
 2. Switchboards and panelboards in accordance with NEC Article 408.6.
 3. Air-conditioning and refrigeration equipment in accordance with NEC Article 440.10.
 4. Elevator control panels in accordance with NEC Article 620.
- 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

DIVISION 26 SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS
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SECTION 26 08 00 – COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1. GENERAL

1.1. RELATED DOCUMENTS

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

1.2. SUMMARY

- A. This Section includes requirements for commissioning the electrical system and its subsystems and equipment. This Section supplements the general requirements specified in Division 01 Section "General Commissioning Requirements."
- B. Related Sections include the following:
 - 1. Division 01 Section "General Commissioning Requirements" for general requirements for commissioning processes that apply to this Section.
- C. The following systems and/or equipment shall be commissioned:
 - 1. Lighting Control System(s)
 - a. Lighting Control Panels
 - b. Occupancy/Vacancy Sensors
 - c. Daylight Sensors
 - d. Wall Switches/Control Stations
 - e. Plug-Load Controlled Receptacle Outlets
 - 2. Platform Lighting System
 - a. Theatrical lighting fixtures
 - b. Lighting controls

1.3. DEFINITIONS

- A. Architect: Includes Architect identified in the Contract for Construction between Owner and Contractor, plus consultant/design professionals responsible for design of electrical systems, electrical, communications, and other related systems.
- B. CxA: Commissioning Authority.
- C. Systems, Subsystems, and Equipment: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, and equipment.

1.4. CONTRACTOR'S RESPONSIBILITIES

- A. The following responsibilities are in addition to those specified in Division 01 Section "General Commissioning Requirements."

B. Electrical Contractor:

1. Provide certified and calibrated measuring instruments and logging devices to record test data, and data acquisition equipment to record data for the complete range of testing for the required test period.

C. Electrical Contractor:

1. With the Mechanical Contractor, coordinate installations and connections between and among electrical and HVAC systems, subsystems, and equipment.
2. Attend TAB verification testing.

1.5. COMMISSIONING DOCUMENTATION

A. The following are in addition to documentation specified in Division 01 Section "General Commissioning Requirements."

B. Test Checklists: CxA with assistance of Contractor shall develop test checklists for electrical systems, subsystems, and equipment, including interfaces and interlocks with other systems. CxA shall prepare separate checklists for each mode of operation and provide space to indicate whether the mode under test responded as required. In addition to the requirements specified in Division 01 Section "General Commissioning Requirements," checklists shall include, but not be limited to, the following:

1. Calibration of sensors and sensor function.
2. Testing conditions under which test was conducted, including (as applicable) ambient conditions, set points, override conditions, and status and operating conditions that impact the results of test.
3. Control sequences for electrical and emergency generator systems.
4. Strength of control signal for each set point at specified conditions.
5. Responses to control signals at specified conditions.
6. Sequence of response(s) to control signals at specified conditions.
7. Electrical demand or power input at specified conditions.
8. Power quality and related measurements.
9. Expected performance of systems, subsystems, and equipment at each step of test.
10. Narrative description of observed performance of systems, subsystems, and equipment. Notation to indicate whether the observed performance at each step meets the expected results.
11. Interaction of auxiliary equipment.

12. Issues log.

1.6. SUBMITTALS

- A. The following submittals are in addition to those specified in Division 01 Section "General Commissioning Requirements."
- B. Testing Procedures: CxA shall submit detailed testing plan, procedures, and checklists for each series of tests. Submittals shall include samples of data reporting sheets that will be part of the reports.
- C. Certificate of Readiness: CxA shall compile certificates of readiness from Contractor certifying that systems, subsystems, equipment, and associated controls are ready for testing.
- D. Certificate of Completion of Installation, Prestart, and Startup: CxA shall certify that installation, prestart, and startup activities have been completed.
- E. Test and Inspection Reports: CxA shall compile and submit test and inspection reports and certificates, and shall include them in systems manual and commissioning report.
- F. Corrective Action Documents: CxA shall submit corrective action documents.

PART 2. PRODUCTS (NOT USED)

PART 3. EXECUTION

3.1. TESTING PREPARATION

- A. Prerequisites for Testing:
 - 1. Certify that electrical systems, subsystems, and equipment have been completed, calibrated, and started; are operating according to the Contract Documents; and that Certificates of Readiness are signed and submitted.
 - 2. Certify that electrical instrumentation and control systems have been completed and calibrated; are operating according to the Contract Documents; and that pretest set points have been recorded.
 - 3. Test systems and intersystem performance after approval of test checklists for systems, subsystems, and equipment.
 - 4. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shut down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
 - 5. Verify each operating cycle after it has been running for a specified period and is operating in a steady-state condition.
 - 6. Inspect and verify the position of each device and interlock identified on checklists. Sign off each item as acceptable, or failed. Repeat this test for each operating cycle

that applies to system being tested.

7. Check safety cutouts, alarms, and interlocks with and life-safety systems during each mode of operation.
8. Annotate checklist or data sheet when a deficiency is observed.
9. Verify proper responses of monitoring and control system controllers and sensors to include the following:
 - a. For each controller or sensor, record the indicated monitoring and control system reading and the test instrument reading. If initial test indicates that the test reading is outside of the control range of the installed device, check calibration of the installed device and adjust as required. Retest malfunctioning devices and record results on checklist or data sheet.
 - b. Report deficiencies and prepare an issues log entry.

3.2. TESTING

- A. Test systems and intersystem performance after test checklists for systems, subsystems, and equipment have been approved.
- B. Perform tests using design conditions whenever possible.
 1. Simulate conditions by imposing an artificial load when it is not practical to test under design conditions and when written approval for simulated conditions is received from CxA. Before simulating conditions, calibrate testing instruments. Set and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- C. Scope of Electrical Contractor Testing:
 1. Testing scope shall include entire electrical installation, from incoming service through distribution systems to each space. It shall include measuring voltages and currents and effectiveness of operational and control functions.
 2. Test all operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. Detailed Testing Procedures: CxA, with Electrical Contractor shall prepare detailed testing plans, procedures, and checklists for electrical systems, subsystems, and equipment.
- E. Electrical System Testing: Electrical Contractor shall prepare a testing plan. Plan shall include the following:
 1. Sequence of testing and testing procedures for each item of equipment and section of wiring to be tested, identified by identification marker. Markers shall be keyed to Drawings for each wiring sector showing the physical location of each item of equipment and electrical wiring test section. Drawings shall be formatted to allow each item of equipment and section of wiring to be physically located and

identified when referred to in the system testing plan.

2. Tracking checklist for managing and ensuring that all wiring systems have been tested.

F. Deferred Testing:

1. If tests cannot be completed because of a deficiency outside the scope of the electrical system, the deficiency shall be documented and reported to Owner. Deficiencies shall be resolved and corrected by appropriate parties and test rescheduled.
2. If the testing plan indicates specific seasonal testing, appropriate initial performance tests shall be completed and documented and additional tests scheduled.

G. Testing Reports:

1. Reports shall include measured data, data sheets, and a comprehensive summary describing the operation of systems at the time of testing.
2. Include data sheets for each electrical systems to verify proper operation of the electrical systems, the system it serves, the service it provides, and its location. Provide space for testing personnel to sign off on each data sheet.
3. Prepare a preliminary test report. Deficiencies will be evaluated by Architect to determine corrective action. Deficiencies shall be corrected and test repeated.

END OF SECTION

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DIVISION 26 SECTION 260919
ENCLOSED CONTACTORS
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SECTION 260919 – ENCLOSED CONTACTORS

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 enclosed contactors for control of electrical circuits rated 600V or less.

1.3. SUBMITTALS

- A. Product Data: Include dimensions and data on features, components, and ratings for enclosed contactors. Provide product data on each type of contactor specified.
- B. Schedule: Prepare and submit a contactor schedule. Include the following information in the schedule.
 - 1. Contactor Identification
 - 2. Operator Type (Mechanical or Electrical)
 - 3. Contact Configuration and Rating
 - 4. Circuit Numbers Controlled
 - 5. Enclosure Rating
 - 6. Control Circuit
 - 7. Voltage
 - 8. Location
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- D. Maintenance Data: For enclosed contactors to include in maintenance manuals specified in Division 01. Include instructions on adjusting, repairing, cleaning and lubricating each control device specified.
- E. Project Record Documents: Accurately record actual locations of each enclosed contactor, and indicate circuits controlled.

1.4. QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed contactors from a single source with total responsibility for compatibility of components specified in this Section.

- B. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA-70, Article 100, for their indicated use and installation conditions by a testing agency acceptable to authorities having jurisdiction.
- C. Comply with NFPA 70, National Electrical Code.
- D. Comply with NEMA ICS 2, Industrial Control Devices, Controllers and Assemblies.
- E. Comply with ANSI/NEMA ICS 6, Enclosures for Industrial Controls and Systems.

1.5. COORDINATION

- A. Coordinate features of devices specified in this Section with systems and components specified in other Sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions.

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. Enclosed Contactors:
 - a. ABB
 - b. Automatic Switch Co.
 - c. Eaton Corporation.
 - d. General Electric
 - e. Hubbell
 - f. Siemens Energy and Automation, Inc.
 - g. Schneider Electric/Square D Co. (Basis of Design)
 - h. Zenith Controls, Inc.

2.2. MULTI-POLE LIGHTING CONTACTORS

- A. Description: Multi-pole enclosed lighting contactors rated 30A, complying with UL 508 and NEMA ICS 2.
- B. Features:
 - 1. Operation: Electrically held.
 - 2. Contact Ampere Rating: UL listed for 30A, consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballasts with 15 percent or less total harmonic distortion of normal load current).
 - 3. Contact Type: Field-convertible double break contacts with N.O. and N.C. indicators. Refer to “Enclosed Contactor Schedule” on the Contract Drawings.
 - 4. Poles: Available in two (2) through twelve (12) pole configurations. Refer to

“Enclosed Contactor Schedule” on the Contract Drawings.

5. Control Circuit: 2-wire or 3-wire.
 6. Control Coil Voltage: Match control power source. Refer to “Enclosed Contactor Schedule” on the Contract Drawings. Provide fused control power transformer for each contactor if required to suit power source.
- C. Accessories: Provide enclosed contactors with the following accessories where indicated on the “Enclosed Contactor Schedule” on the Contract Drawings.
1. On/off pushbutton
 2. Hand-off-automatic selector switch
 3. Red “On” pilot light, green “Off” pilot light
 4. Auxiliary contacts (one N.O., one N.C.)
- D. Basis of Design: Provide Square D Company Type “L” multi-pole contactors, or approved equal by acceptable manufacturer. Provide enclosure suitable for installed location in accordance with paragraph “Enclosures”, this Section.

2.3. ENCLOSURES

- A. Description: All contactors shall be mounted in enclosures, flush or surface mounted as required. Provide flush-mounted enclosures for contactors in finished locations.
- B. Enclosures shall comply with requirements of NEMA 250 – “Enclosures for Electrical Equipment”, and NEMA ICS 6 – “Enclosures Standard”.
- C. Enclosures shall be provided in accordance with the following requirements in order to meet environmental conditions at the installed location of each motor controller.
1. Dry, Interior Locations: NEMA Type 1.
 2. Damp or Wet Locations: NEMA Type 3R.

PART 3. EXECUTION

3.1. INSTALLATION

- A. Install equipment level and plumb and according to manufacturer's written instructions.
- B. Mount enclosed contactors according to manufacturer's written instructions and requirements in Division 26 Section 260500, “Common Work Results for Electrical”.
- C. All products and devices shall be installed in accessible locations.
- D. Locate electrically held contactors where the eventual vibration and noise they will produce will not be objectionable to building occupants.

- E. Provide enclosures for each individual component.

3.2. CONTROL WIRING INSTALLATION

- A. Install wiring between sensing and control devices according to manufacturer's written instructions and as specified in Division 26 Section 260519, "Low-Voltage Electrical Power Conductors and Cables".
- B. Wiring Method: Install all wiring in raceway as specified in Division 26 Section 260533, "Raceways and Boxes for Electrical Systems", unless run in accessible ceiling space and gypsum board partitions.
- C. Bundle, train, and support wiring in enclosures.
- D. Ground equipment.
- E. Connections: 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.
- F. Connect control devices to systems controlled, to achieve proper system operation.

3.3. IDENTIFICATION

- A. Provide equipment nameplate(s) to identify equipment designation, power supply circuit, and load(s) controlled for each enclosed contactor. Refer to the Contract Drawings for additional information.
- B. Identify power and control wiring according to Division 26 Section 260553, "Electrical Identification".

3.4. FIELD QUALITY CONTROL

- A. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.
- B. Inspect control components for defects and physical damage, testing, laboratory labeling, and nameplate compliance with the Contract Documents.
- C. Check tightness of electrical connections with torque wrench calibrated within previous six months. Use manufacturer's recommended torque values.
- D. Electrical Tests: Use particular caution when testing devices containing solid-state components. Perform the following according to manufacturer's written instructions:
 - 1. Continuity tests of circuits.
 - 2. Operational Tests: Set and operate devices to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions. Include testing of devices under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

- E. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.
- F. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
- G. Reports: Provide written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.5. CLEANING

- A. Clean equipment and devices internally and externally using methods and materials recommended by manufacturers, and repair damaged finishes.

3.6. DEMONSTRATION

- A. Train Owner's maintenance personnel as specified below:
 - 1. Train Owner's maintenance personnel on troubleshooting, servicing, adjusting, and preventive maintenance. Provide a minimum of two hours' training.
 - 2. Training Aid: Use the approved final version of maintenance manuals as a training aid.
 - 3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

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. 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. Related Sections include the following:
 - 1. Division 26 Section 260500, “Common Work Results for Electrical”, for submittal requirements, general materials, installation requirements, Record Document requirements.
 - 2. Division 26 Section 260553, “Identification for Electrical Systems”, for labeling materials.
 - 3. Division 26 Section 262726, “Wiring Devices”, for line voltage wallbox switches controlling lighting fixtures.
 - 4. Division 26 Section 265100, “Interior Lighting” for interior lighting fixtures and exterior building-mounted lighting fixtures controlled by network lighting controls.
 - 5. Division 26 Section 265600, “Exterior Lighting” for exterior lighting fixtures controlled by network lighting controls.

1.2. SUMMARY

- A. This Specification provides the requirements for the installation, programming and configuration of a complete and operational network lighting control system. The system shall include, but not be limited to: server, software, bus supplies, network wall switches, network occupancy sensors, network day-light sensors, raceway, wire & cable and accessories required to furnish a complete and operational network lighting control system.
- B. The network lighting control system shall be a microprocessor-based network system. All digital lighting system components shall be tested and cross-listed as compatible to ensure a fully functional system is setup and installed.
- C. Furnish and install a complete network lighting control system as described herein and as shown on the plans to be: wired, connected, and left in first class operating condition. Include sufficient control unit(s), wall stations, sensors, wiring, terminations, electrical boxes & cabinets and all other necessary material for a complete operating system.

1.3. REFERENCES

- A. American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE):
 - 1. C62.41 – Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
 - 2. ANSI C12.20 – Accuracy Standards
- B. National Electrical Manufacturers Association (NEMA):

1. WD1 – General Color Requirements for Wiring Devices.
 2. WD6 – Dimensional Specifications.
- C. Underwriters Laboratories, Inc. (UL):
1. 94 – Flammability Rating
 2. 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
 3. UL498 – Standard for Attachment Plugs and Receptacles.
 4. 508 – Standard for Industrial Control Equipment.
 5. UL514C – Standard for Non-metallic Outlet Boxes, Flush Device Boxes, and Covers.
 6. 916 – Energy Management Equipment.
 7. 924 – Emergency Lighting and Power Equipment
 8. 1310 – Class 2 Power Units.
 9. 1472 – Solid-State Dimming Controls.

1.4. SYSTEM DESCRIPTION

- A. The lighting control system specified in this section shall provide time-based, sensor-based (both occupancy and daylight), and manual lighting control.
- B. The system shall be capable of turning lighting loads on/off as well as dimming lights if lighting load is capable of being dimmed.
- C. All control system devices shall be networked together enabling digital communication and shall be individually addressable.
- D. The system shall be capable of enabling stand-alone groups of devices to function in some default capacity even if network connectivity to the greater system is lost.
- E. System shall facilitate remote operation via a computer connection.

1.5. SUBMITTALS

- A. Submit under provisions of Division 01.
- B. Specification Conformance Document: Indicate whether the submitted equipment:
 1. Meets specification exactly as stated.
 2. Meets specification via an alternate means and indicate the specific methodology used.
- C. Product Data: Catalog cut sheets with performance specifications demonstrating compliance with specified requirements.
- D. Shop Drawings: Provide a complete set of detailed installation drawings specific to this project that include assemblies, schedules and details as required to fully define the installation, testing, startup and other elements necessary to create a complete lighting management control system in accordance with this Specification, including:

1. Schematic (one-line diagram) of system.
2. Large scale floor plans – Indicate location, orientation, and coverage area of each sensor, group designations, etc.
3. Address Drawing – Reflected Ceiling Plan (RCP) indicating all static addresses for all addressable devices, including lighting fixtures, control devices, sensors, relays, network devices, etc.
4. Wiring Diagrams and Schematics – Provide detailed wiring diagrams for each room type. Generic diagrams are not acceptable. Coordinate nomenclature and presentation with a block diagram, and differentiate between manufacturer-installed and field-installed wiring.

E. Samples:

1. Samples showing available color and finish selections for controls shall be submitted to the Architect.
2. Provide one sample of each field-connected device to the Division 26 Contractor for their familiarization.

F. Certifications: Submit a certification from the major equipment manufacturer indicating that the proposed supervisor of installation and the proposed performer of contract maintenance is an authorized representative of the major equipment manufacturer. Include names and addresses in the certification.

G. Sequence of Operation: To describe how each area operates and how any building wide functionality is described.

1.6. CLOSEOUT SUBMITTALS

A. Start-up and Commissioning Closeout Documentation

1. Lighting Control System Manufacturer to provide enhanced start-up documentation that details the start-up procedure being performed including a process to follow, details on tests performed and an area that documents any test results.
2. Contractor shall submit startup/commissioning worksheets, which must be completed prior to factory start-up.

B. Software and Firmware Operational Documentation

1. Software operating and upgrade manuals.
2. Program software backup: On a compact disc complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

C. Record Documents

1. Drawings showing the actual installed hardware and configuration to include: power circuits, control device identification, schedules of control functions, and static addresses for routers, LED drivers, controllers, sensors, and other lighting control devices.

D. Operation and Maintenance Data

1. For lighting controls to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 include the following Software manuals.
 - a. Adjustments of scene preset controls, fade rates and fade overrides.
 - b. Operation of adjustable zone controls.
 - c. Testing and adjusting of emergency lighting and night lighting features.
 - d. Operation manuals covering the installed lighting management system.
 - e. A complete set of Record Drawings in both hard copy (minimum 30"x42") and electronic files in .pdf and .dwg format.

1.7. QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Minimum five (5) years' experience in manufacture of network lighting control systems.
2. Furnish electrical control equipment for complete installation and single source responsibility of lighting control.
3. Qualified to supply specified products and to honor claims against product presented in accordance with warranty.

B. Lighting Control System Components:

1. All applicable products must be UL / CUL Listed or other acceptable national testing organization.
2. Listed by UL specifically for the required loads. Provide evidence of compliance upon request.
3. Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Authorities Having Jurisdiction, and marked for intended use.
4. All sensors and related relays shall be compatible with the specific lighting types controlled.
5. All sensors shall be of the same manufacturer, mixing brands of sensors is not acceptable
6. All sensors and controlled modules connected to more than 50 VAC shall be listed by Underwriters Laboratories.
7. All sensors and related equipment shall have a five-year warranty.

C. Installer Qualifications:

1. Installers shall be factory-trained by the network lighting control system manufacturer.

1.8. DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Include installation, programming, and maintenance instructions.

1.9. PROJECT CONDITIONS

- A. System components shall have ten-year operational life while operating continually at any temperature in an ambient temperature range of 0 degrees C (32 degrees F) to 40 degrees C (104 degrees F) and 90 percent non-condensing relative humidity.
- B. Do not install equipment until the above conditions can be maintained in spaces to receive equipment.
- C. Do not install products under environmental conditions outside manufacturer's absolute limits.
- D. Lighting control system must be protected from dust during installation.
- E. Components shall be designed and tested to withstand discharges without impairment of performance when subjected to discharges of 15,000 volts per IEC 801-2.

1.10. WARRANTY

- A. Provide manufacturer's warranty covering 5 years from date of purchase with factory startup.
 - 1. Five (5) year limited parts warranty, including:
 - a. Years 1-2:
 - i. 100 Percent Replacement Parts for Manufacturer Lighting System Components
 - ii. 100 Percent Manufacturer Labor Coverage to Troubleshoot and Diagnose a Lighting Issue
 - iii. First-Available Onsite or Remote Response Time
 - b. Years 3-5: 100% Replacement Parts Coverage

1.11. EXTRA MATERIALS

- A. Make ordering of new equipment for expansions, replacements, and spare parts available to end-user, qualified dealer or installer.
- B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents:
 - 1. Occupancy/Vacancy Sensors: Quantity equal to one for every 20 of each type installed, but no fewer than one unit of each type.
 - 2. Daylight Sensors: Quantity equal to one unit for every 20 sensors installed, but no fewer than one unit.
 - 3. Power Packs: Quantity equal to one unit for every 50 modules installed, but no fewer than one of each type.
 - 4. Wall Switches: Quantity equal to one unit for every 30 wall switches installed, but no fewer than one of each type.
 - 5. Emergency Lighting Interfaces: Quantity of two of each type installed.

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 the following:
1. nLight/Acuity Controls
 2. Lutron Electronics, Inc.
 3. Hubbell Lighting Controls
 4. Cooper (Eaton) Lighting Controls
 5. WattStopper
 6. Leviton Manufacturing Co, Inc.

2.2. GENERAL SYSTEM REQUIREMENTS

- A. Lighting control system will have: a networked backbone to allow for remote or time-based operation, intelligent lighting control devices capable of communicating on a digital network, and a system capable of operating in standalone lighting control zones.
- B. Intelligent lighting control devices shall consist of but not be limited to: occupancy sensors, photocell sensors, relays, dimming outputs, low voltage switches, manual switch stations, manual dimming stations, graphic wall control, and intelligent lighting fixtures.
- C. System shall be capable of integrating directly with intelligent LED luminaires in a fashion that integration to the system be achieved through the use of interconnecting Cat5 cable.
- D. Lighting control zones shall consist of one or more intelligent lighting control components, be capable of stand-alone operation, and be capable of being connected to a higher-level network backbone.
- E. All devices within the lighting control system shall be daisy-chained together with Cat5 low voltage cabling in any order
- F. Lighting control zone shall be capable of automatically configuring itself for default operation without any start-up labor required.
- G. Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure with the backbone network or if the management software becomes unavailable.
- H. All switching and dimming for a specific lighting zone shall take place within the device located in the zone itself to facilitate system robustness and minimize wiring requirements. Specific applications that require centralized or remote switching shall be capable of being accommodated.
- I. System shall have a primary network control device that is capable of accessing and controlling connected system devices and linking into an Ethernet LAN.
- J. System shall have a network communication device that routes communication between control zones and distributes power across up to 8 directly connected zones.
- K. System shall have a web-based software management program that enables remote system

control, status monitoring, and creation of lighting control profiles.

- L. System shall be capable of operating a lighting control zone according to a sequence of operation. Operating modes should be utilized only in manners consistent with local code.
 - 1. Auto-On / Auto-Off (via occupancy sensors)
 - 2. Manual-On / Auto-Off
 - 3. Auto-to-Override On
 - 4. Manual-to-Override On
 - 5. Auto On/Predictive Off
 - 6. Multi-Level On (multiple lighting levels per manual button press)
- M. Control software shall enable logging of system performance data and presenting information in a web-based graphical format or downloadable .CSV file.
- N. Control software shall enable integration with a BMS via BACnet IP.

2.3. CENTRALIZED SYSTEM CONTROL

- A. System shall have a centralized processor capable of communicating and controlling downstream system control devices and linking into an Ethernet.
- B. Control modules shall be powered by low voltage, and have a backlit LCD display screen.
- C. User control shall be made via finger-touch buttons with no moving parts. Buttons shall be capable of being locked for security.
- D. Devices shall have RJ-45 ports for connection to other backbone devices or for connection directly to lighting control zones.
- E. Devices shall automatically detect all downstream devices.
- F. Devices shall have a standard and astronomical internal time clock capable of providing time based command to all devices downstream of control module.
- G. Devices shall have an RJ-45 10/100 BaseT Ethernet connection.
- H. Devices shall be capable of using a dedicated or DHCP assigned IP address.

2.4. CENTRALIZED COMMUNICATION DEVICES

- A. Devices shall have multiple RJ-45 ports.
- B. Devices shall be capable of aggregating communication from multiple lighting control zones for purpose of minimizing backbone wiring requirement back to centralized system control.
- C. Devices shall be powered with Class 2 low voltage supplied locally via a directly wired power supply or delivered via a Cat5 connection.
- D. Devices shall be capable of redistributing power from its local supply and connect lighting

control zones with excess power to lighting control zones with insufficient local power. This architecture also enables loss of power to a particular area to be less impactful on network lighting control system.

2.5. POWER PACKS

- A. Power packs shall incorporate one or more Class 1 relays and contribute low voltage power to the rest of the system. Power supplies shall provide system power only, but are not required to switch line voltage circuit. Auxiliary relay packs shall switch low voltage circuits only.
- B. Power packs shall accept and switch 120VAC or 277 VAC, be plenum rated, and provide Class 2 power for multiple sensors.
- C. All power packs shall have two (2) RJ-45 ports.
- D. Power packs shall securely mount to junction location through a threaded ½ inch chase nipple. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads.
- E. Power packs shall incorporate a Class 1 relay and an AC electronic switching device. The AC electronic switching device shall make and break the load, while the relay shall carry the current in the on condition. This system shall provide full 20 Amp switching of all load types, and be rated for 400,000 cycles.
- F. Power packs shall be single circuit, or two circuits. When two circuit power packs, the power packs must be wired directly to circuit breaker. Otherwise, power packs may be wired on the line or load side of the local switch.
- G. Power packs for plug load control shall be rated for switching 20-Amperes.
- H. All applicable products must be UL / CUL Listed or other acceptable national testing organization.
- I. Slave modules shall be available for switching additional circuits. Slave module has same construction and specification as control module except without power supply function.

2.6. OCCUPANCY SENSORS

- A. Occupancy sensor system shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.
- B. Sensors shall utilize passive infrared technology, which detects occupant motion, to initially turn lights on from an off state; thus preventing false on conditions.
- C. For applications where a second method of sensing is necessary to adequately detect maintained occupancy, sensors with an additional technology shall be used.
- D. Sensor shall be capable of mounting in multiple locations:
 - 1. Ceiling Mount

2. Corner Mount
 3. Wall Mount with on/off switch
 4. Fixture Mount
- E. Sensor shall be available with different sensing technologies:
1. Passive Infrared (PIR).
 2. Microphonics
 3. Ultrasonic
- F. Low voltage sensors shall receive communication and Class 2 low voltage power via standard Cat5 low voltage cabling with RJ-45 connectors.
- G. Line voltage sensors shall be capable of switching 120/277 VAC. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, and ¼ HP motors.
- H. All sensors shall have two (2) RJ-45 Ports.
- I. Sensors shall turn lights on only upon infrared detection.
- J. Sensors shall indicate detected motion via a red LED.
- K. Sensor controls shall be behind cover to resist tampering.
- L. Sensors shall have optional features for on/off photocell control, automatic dimming control photocell, high/low occupancy based dimming, and usage in low temperature/high humidity environments.
- M. Sensors with dimming can control 0-10 VDC dimmable LED drivers by sinking up to 20 mA of Class 2 current.
- N. The occupancy sensor system shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.
- O. Sensors in damp and/or high humidity locations, e.g. rooms with showers, shall be suitable for use in high humidity environments.
- P. Sensors in wet locations, e.g. outdoors, shall be equipped with watertight/weatherproof enclosures and rated for use in low temperature/high humidity environments.

2.7. DAYLIGHT CONTROLS

- A. Low voltage photocell shall accept 12 to 24 VAC or VDC and provide a relay for interface with remote switching system. Sensors shall interface with occupancy sensors, directly with power pack or other system as shown. Sensors shall control 0 to 10 VDC dimmable LED drivers by sinking up to 20 mA of class 2 current.
- B. Low voltage dimming sensors set point shall be automatically calibrated through the sensor's microprocessor by initiating the "Automatic Set-point Programming" procedure. Min and max dim settings as well as set-point may be manually entered.

- C. Photocell shall provide for an on/off set-point, and a deadband to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.
- D. Deadband setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space.
- E. Dual zone option shall be available for photocell, dimming, or combination units. The second zone shall be controlled as an “offset” from the primary zone and shall be the zone farthest from the natural light source.
- F. Line voltage versions of the above described photocell and combination photocell/dimming sensors shall be capable of switching both 120 VAC and 277 VAC and run off of 50/60 Hz power. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, and ¼ HP motor load.
- G. Line voltage versions of the above described dimming sensors shall be capable of powering off 120/277 VAC.
- H. All sensors shall have two (2) RJ-45 jacks.

2.8. WALL SWITCHES, DIMMERS, AND SCENE CONTROLLERS

- A. All switches shall recess into a single-gang switch box and fit a standard decorator style opening.
- B. Communication and low voltage power shall be delivered to each device via standard Cat5 low voltage cabling with RJ-45 connectors.
- C. All switches shall have two (2) RJ-45 ports.
- D. All switches shall provide toggle switch control. Dimming control and low temperature/high humidity operation are available options.
- E. Devices with mechanical push-buttons shall be made available with custom button labeling.
- F. Devices with a single on button shall be capable of selecting all possible lighting combinations for a bi-level lighting zone such that the user confusions as to which of two buttons controls which load is eliminated.
- G. Devices shall have two to four buttons for selecting programmable lighting control profiles or acting as on/off switches.
- H. Devices shall be capable of selecting a lighting profile be run by the system’s upstream processor so as to implement selected lighting profile across multiple zones.
- I. Switch finishes shall be as selected by Architect.
- J. Refer to details and the “Network Wall Switches Schedule” of the Contract Drawings for specific requirements.

2.9. TOUCH SCREEN WALL SWITCHES

- A. Devices shall have a 3.5” full color touch screen for selecting up to sixteen (16) programmable lighting control presets or acting as up to sixteen (16) on/off/dim control switches.
- B. Devices shall enable configuration of lighting presets, switches and dimmers via password protected screen setups.
- C. Devices shall have full alpha-numeric nomenclature for scenes and lighting channels.
- D. Devices shall enable user supplied .jpg screen saver image to be uploaded.
- E. Devices shall have two (2) RJ-45 ports.
- F. Switch finishes shall be as selected by Architect.
- G. Refer to details and the “Network Wall Switches Schedule” of the Contract Drawings for specific requirements.

2.10. RELAY AND DIMMING PANELS

- A. Panels shall incorporate up to forty-eight (48) field-configurable latching relays at 120/277 VAC or twenty-four (24) dual phase 208/480 VAC relays. Relays shall be rated to switch up to 30A ballast loads at 277 VAC.
- B. All relays shall be individually programmable, and shall have local manual override lever.
- C. Panels shall have one (1) 0-10 VDC dimming output for each relay.
- D. Power shall be powered from an integrated 120/277 VAC supply.
- E. Panel shall have two (2) RJ-45 ports and be capable of operating as a networked device.
- F. Panels shall have hinged keylock covers and field-installed voltage barrier(s) for normal/emergency use, or mixed voltage use.
- G. Panels shall be UL924 listed for switching emergency circuits.

2.11. AUXILIARY INPUT / OUTPUT DEVICES

- A. Devices shall be plenum rated and be inline wired, screw mountable, or have an extended chase nipple for mounting to a ½” knockout.
- B. Devices shall have two (2) RJ-45 ports.
- C. Communication and low voltage power shall be delivered to each device via standard Cat5 low voltage cabling with RJ-45 connectors.
- D. Devices shall have a dimming control output that can control 0-10 VDC dimmable LED drivers by sinking up to 20 mA of current.

- E. Devices shall have an input that read a 0-10 VDC signal from an external device.
- F. Device shall have a switch input that can interface with either a maintained or momentary switch and run a switch event, or run a local/remote control profile.
- G. A specific I/O device shall sense state of low voltage outdoor photocells.

2.12. BUILDING MANAGEMENT SYSTEM COMPATIBILITY

- A. System shall provide a BACnet IP gateway as a downloadable software plug-in to its management software. No additional hardware shall be required.
- B. BACnet IP gateway software shall communicate information gathered by networked system to other building management systems
- C. BACnet IP gateway software shall translate and forward lighting relay and other select control commands from BMS system to networked control devices.

2.13. SYSTEM ENERGY ANALYSIS & REPORTING SOFTWARE

- A. System shall be capable of reporting lighting system events and performance data back to the management software for display and analysis.
- B. Intuitive graphical screens shall be displayed in order to facilitate simple viewing of system energy performance.
- C. An “Energy Scorecard” shall be display that shows calculated energy savings in dollars, KWHr, or CO2.
- D. Software shall calculate the allocation of energy savings to different control measures.
- E. Energy savings data shall be calculated for the system as a whole or for individual zones.
- F. User shall be able to customize the baseline run-time hours for a space.
- G. User shall be able to customize up to four time-of-day billings rates and schedules.

2.14. MANAGEMENT SOFTWARE

- A. Every device parameter shall be available and configurable remotely from the software.
- B. The following status monitoring information shall be made available from the software for all devices for which is applicable:
 - 1. Current Occupancy Status
 - 2. Current PIR Status
 - 3. Current Microphonic Status
 - 4. Remaining Occupancy Time Delay
 - 5. Current Photocell Reading
 - 6. Current Photocell Inhibiting State
 - 7. Photocell Transitions Time Remaining

8. Current Dim Level
 9. Device Temperature
 10. Device Delay Status
- C. The following device identification information shall be made available via the software:
1. Model Number
 2. Model Description
 3. Serial Number
 4. Manufacturing Date Code
 5. Custom Label
 6. Parent Network Device
- D. Software shall provide at least three permission levels for users.

PART 3. EXECUTION

3.1. EXAMINATION

- A. Examine substrate areas and conditions, with installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Lighting Management System.
- B. Examine rough-in for the network lighting controls to verify actual locations of conduit connections before equipment installation.
- C. Examine walls, floors, ceilings, etc. for suitable conditions where network lighting control equipment will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. INSTALLATION

- A. Install equipment in accordance with manufacturer's installation instructions.
- B. Provide complete installation of system in accordance with Contract Documents.
- C. Provide equipment at locations and in quantities indicated on Drawings. Provide any additional equipment required to provide control intent.
- D. Secure equipment to building structural elements and support according to requirements of Division 26 Section "Hangers and Supports for Electrical Systems".
- E. In order for the system to be fully commissioned and operating to specification, a database will need to be created. It is critical that the manufacturer receive information on load and control functionality so that the database can be written and fully tested by the manufacturer.
- F. Define each dimmer's/relay's load type, assign each load to a zone, and set control functions.

G. Occupancy/Vacancy Sensors:

1. Install system components in accordance with Manufacturer's instructions. Sensor locations are approximate and are designed according to the specified manufacturer.
2. Arrange a pre-installation meeting with the manufacturer's factory authorized representative, at the Owner's facility, to verify placement of sensors and installation criteria.
3. Locate and aim sensors in the correct location required for complete and proper volumetric coverage within the range of coverage(s) of controlled areas per the manufacturer's recommendations. Rooms shall have ninety (90) to one hundred (100) percent coverage to completely cover the controlled area to accommodate all occupancy habits of single or multiple occupants at any location within the room(s). Provide additional sensors as required to properly and completely cover the respective room.
4. Sensors shall be mounted where they will not receive light directly from a light source or reflecting source.
5. Sensors shall be mounted at least 4 feet from HVAC vents to avoid air current interference.
6. Sensors in damp and/or high humidity locations, e.g. rooms with showers, shall be suitable for use in high humidity environments.
7. Sensors in wet locations, e.g. outdoors, shall be equipped with watertight/weatherproof enclosures and rated for use in low temperature/high humidity environments.
8. Mounting of passive infrared and dual technology sensors where columns, doors, walls, or other obstructions will block the sensor's field of view should be avoided.
9. Passive infrared coverage should not extend through doorways. Masking inserts shall be installed for PIR coverage rejection to prevent false tripping.
10. Sensors shall be positioned so that lights are activated when a person is 2 feet or less through any doorway.
11. Sensors installed in spaces without ceilings shall be installed at the same elevation as the suspended lighting fixtures in the space.

H. Daylight Sensors:

1. In order for the exterior daylight sensor to respond to daylight during the entire daylight period, the sensor should face north so that in the morning it will see daylight from the east and in the evening it will see daylight from the west. Directing the sensor due north also minimizes direct lighting exposure to the sensor which could overload the sensor.
2. Interior sensors work mainly with diffused light, as such, they have a much higher lighting gain than exterior sensors. Electric light sources can affect these sensors unless the sensors are shielded from the light given off by electric light sources.
3. Ensure that daylight sensor placement minimizes sensors view of electric light sources; ceiling mounted and fixture-mounted daylight sensors shall not have direct view of luminaires.

I. Label all wiring, cables and enclosures in accordance with Division 26 Section "Identification for Electrical Systems".

J. Systems Integration:

1. Equipment Integration Meeting Visit

- a. Facility Representative to coordinate meeting between Facility Representative, Lighting Control System Manufacturer, and other related equipment manufacturers to discuss equipment and integration procedures.

K. Wiring Method:

1. Bus control wire shall be run in accordance with the requirements of this spec, local jurisdiction requirements, or Manufacture's written requirements whichever is more stringent.
2. Conductors to Class 2 occupancy sensors or photo-sensors not exceeding 12 feet may be installed in accordance with NEC Article 725 for Class 2 circuits and the support requirements of this Section.
3. Class 2 control cable over 12 feet in length shall be run in conduit or bundled and run in accordance with communication cable requirements.
4. Free-run Class 2 cable shall be supported at a minimum of every 6 feet and shall be run above ductwork and other equipment at the truss level to reduce the exposure to damage.
5. Cable supports shall use double wire ties or equivalent methods that prevent direct contact between the cable and sharp and/or hard surfaces such as running thread rods, pipe supports, and suspended ceiling wires.
6. Cable supports shall not pinch or overly tighten the cable.
7. Cable shall not be supported by ductwork, ceiling tiles, or other equipment.
8. Connections to sensors and other devices shall be strain relieved to the device or a nearby support.
9. When mounted in a ceiling tile the cable shall include at least 6 feet of coiled cable to allow tiles to be relocated.
10. Comply with manufacturer's written instructions for wiring installation or this spec whichever is more stringent.
11. Install bus wire with the minimum number of splices.

L. Wiring Within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to equipment manufacturer's written instructions.

M. Surge Protection: Install field-mounted transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.

N. Equipment Grounding: Provide low-impedance "hard" copper earth grounding to ballasts, fixtures, and control mounting boxes in accordance with ballast, lamp, and control manufacturer's requirements. Floating fixture strike plates and high-impedance "safety grounds" are generally not acceptable and standard UL listed safety grounds may not be sufficient.

O. 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.

3.3. IDENTIFICATION

- A. Identify components, and power and control wiring in accordance with Division 26 Section 260553, “Identification for Electrical Systems”.
- B. Identify all ceiling mounted controls in blank covered boxes with network number, device address, and type of control located in box.
- C. Label each network wiring pair within 6 inches of connection to control network bus supply or termination block. Each control network wire pair shall be labeled in accordance with Division 26 Section 260553, “Identification for Electrical Systems”, and shall include the electrical power panel name and circuit number with which the wire pair is pulled.

3.4. SERVICE AND SUPPORT

- A. A Digital-Network Lighting Control System requires multiple site visits for proper startup. The first site visit ensures that the contractor is trained to install the system correctly. The second visit starts up the system and ensures that the system is operating per specification. The third visit trains the owner/end user on system operation and functionality.
- B. Startup and Programming
 - 1. Provide factory certified field service engineer to make minimum of three site visits to ensure proper system installation and operation under following parameters
 - a. Qualifications for factory certified field service engineer:
 - i. Minimum experience of 2 years training in the electrical/electronic field.
 - ii. Certified by the equipment manufacturer on the system installed.
 - b. Make first visit prior to installation of wiring. Review the following:
 - i. Low voltage wiring requirements.
 - ii. Separation of power and low voltage/data wiring.
 - iii. Wire labeling.
 - iv. Lighting Management Panel locations and installations.
 - v. Control locations.
 - vi. Computer jack locations.
 - vii. Load circuit wiring.
 - viii. Network wiring requirements.
 - ix. Connections to other equipment.
 - x. Installer responsibilities.
 - xi. Power Panel locations.
 - c. Make second visit upon completion of installation of Network Lighting Control System:
 - i. Verify connection of power wiring and load circuits.
 - ii. Verify connection and location of controls.
 - iii. Energize Lighting Management Panels and download system data program.
 - iv. Address devices.
 - v. Verify proper connection of panel links (low voltage/data) and address panel.
 - vi. Download system panel data to dimming/switching panels
 - vii. Check dimming panel load types and currents and supervise

- removal of by-pass jumpers.
- viii. Verify system operation control by control.
- ix. Verify proper operation of manufacturers interfacing equipment.
- x. Verify proper operation of manufacturers supplied PC and installed programs.
- xi. Configure initial groupings of ballast for wall controls, daylight sensors and occupant sensors.
- xii. Initial calibration of sensors.
- xiii. Obtain sign-off on system functions.
- d. Make third visit to demonstrate and educate Owner's representative on system capabilities, operation and maintenance. See requirements below.

2. Startup

- a. Software configuration
 - i. Naming and association of areas and lighting zones.
- b. After Hours Start-up
 - i. Provide factory certified Field Service Engineer to perform manufacturer's start-up procedures outside normal working hours (Monday through Friday, 7a.m. to 5 p.m.)

C. Training of customer representatives for Lighting Management Software

D. Provide factory direct technical support hotline 24 hours per day, 7 days per week.

3.5. FIELD QUALITY CONTROL

A. Manufacturer Services

1. Aim and Focus Visit

- a. Facility Representative to coordinate on-site meeting with Lighting Control System Manufacturer and Architect/Engineer to make required lighting adjustments to the system for conformance with the Architect/Engineer's original design intent.

B. Complete installation and startup checks in accordance with manufacturer's written instructions to include the following:

- 1. Prefunction - Compliance inspection of all materials, controls, light fixtures.
- 2. Activate light fixtures prior to control system activation and verify that all light sources are operating at 100%.
- 3. Test that control bus wiring is free of wire-ground and wire-wire shorts and AC line voltage before connecting to the Bus Supply.

C. Remove and replace lighting control devices where test results indicate that they do not comply with specified requirements.

D. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

- E. Reports: Prepare written reports of tests, inspections, verifications and observations indicating and interpreting results. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments
- F. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- G. Verify normal operation of each fixture after installation.
- H. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify normal transfer to backup source and retransfer to normal.
- I. If adjustments are made to lighting control system, retest to demonstrate compliance with standards.

3.6. DEMONSTRATION & TRAINING

- A. Training Visit
 - 1. Lighting Control System Manufacturer to provide 2 days (minimum 12 hours) additional on-site system training to site personnel.
- B. On-Site Walkthrough
 - 1. Lighting Control System Manufacturer to provide a factory certified Field Service Engineer to demonstrate system functionality to the Commissioning Agent.
- C. Video Recordings
 - 1. Provide video recordings of on-site system training sessions in accordance with Division 26 Section 26500, "Common Work Results for Electrical".

3.7. MAINTENANCE

- A. Capable of providing on-site service support within 24 hours anywhere in continental United States.
- B. Offer renewable service contract on yearly basis, to include parts, factory labor, and annual training visits. Make service contracts available up to ten years after date of system startup.
- C. System Optimization Visit
 - 1. Lighting Control System Manufacturer to visit site **[three (3)] [six (6)]** months after system start-up to evaluate system usage and discuss opportunities to make efficiency improvements that will fit with the current use of the facility.

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 “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 for service provisions.
- B. The Contractor shall provide all materials and labor for complete empty conduit power, telephone and CATV distribution systems as shown on the drawings and as specified herein.

1.3. RELATED WORK SPECIFIED ELSEWHERE IN DIVISION 26

- A. Division 26 Section 260500, “Common Work Results for Electrical”.
- B. Division 26 Section 260573, “Power System Studies”.
- C. Division 26 Section 260533, “Raceways and Boxes for Electrical Systems”.
- D. Division 26 Section 262726, “Wiring Devices”.
- E. Division 26 Section 260543, “Underground Ducts and Raceways for Electrical Systems”.
- F. Division 26 Section 260526, “Grounding and Bonding for Electrical Systems”.

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 serving 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 document 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 if required) 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 Delaware Municipal Electric Corporation (DEMEC).
- B. Comply with the requirements of NFPA 70, National Electrical Code.
- C. Comply with the NECA 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 Delaware Municipal Electric Corporation (DEMEC).
- B. The point of contact at the electric utility company is:
 - 1. Name: Josh Little
 - 2. Email: jlittle@smyrna.delaware.gov
 - 3. Phone Number: (302) 339-2332
- C. Coordinate service entrance equipment and layout with power company prior to ordering or installing any service entrance equipment.
- D. Furnish and install all incoming raceway.
- E. Coordinate cable, conduit, lug sizes, etc., for proper interface between utility-owned/installed equipment and Contractor-installed equipment.
- F. Provide pad for utility company's transformer as required by the Utility. If utility company furnishes pre-cast transformer pad, schedule pick up/delivery with utility company.
- G. Provide grounding and clearances as required by the Utility.
- H. 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.
- I. The Contractor shall ascertain from the utility companies, the available short circuit fault current.
- J. Equipment for Utility Company's Electric Metering:
 - 1. Current-Transformer Cabinets: Comply with requirements of electrical power utility company.
 - 2. Meter Sockets: Comply with requirements of electrical power utility company.
 - 3. Housing: NEMA 250, Type 3R enclosure.
- K. All mainline disconnects, tap boxes, C/T cabinets, meter sockets, and other service equipment shall be approved by the utility company prior to ordering.

2.2. TELECOMMUNICATIONS COMPANY PROVISIONS

- A. Refer to Technology Contract Drawings.
- B. Telecommunications Service Wall Space: Provide a wall-mounted ¾-inch fire-retardant painted plywood backboard, 8 feet high x 4 feet wide, as shown at location indicated on the drawings.

- C. Provide adjacent to backboard two duplex convenience NEMA 5-20R receptacles connected to the emergency power system. Provide (2) 12 AWG and (1) 12 AWG grounding conductor in ¾-inch conduit from receptacles to nearest 120 volt emergency power panel.
- D. Provide adjacent to the backboard, one 4 AWG copper grounding conductor extended from the building's service ground point.
- E. Provide conduit sleeves where cable is extended through partitions, walls, or floor slabs. Fire seal all openings after cable is installed.
- F. Incoming Telecommunications service:
 - 1. Coordinate incoming telecommunications service requirements with area public telecommunications system utility. Provide two (2) 4-inch Schedule 40 PVC underground conduits with pull cords from the telecommunications service equipment backboard to the vicinity of the pad-mounted transformer unless otherwise indicated on the Drawings. Terminate conduits in the exact location and manner as directed by the telecommunications company.
 - 2. Provide pre-cast pulling handholes in duct run in location(s) as directed if deemed necessary by the telecommunications utility. Size of handholes (L x W x H) shall be as required by the utility. Handholes installed in roadways shall be H20 roadway type.
 - 3. Extend two (2) 4-inch PVC Schedule 40 underground service conduits along with primary electrical feeder from pad-mounted transformer location to 5'-0-inches beyond property line, or as indicated on the Drawings, then capped and stubbed.
 - 4. In addition to the above requirements, install raceways in maximum lengths as required by telecommunications company and a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements.
- G. Coordinate incoming raceway with telecommunications utility company. Provide required conduit sizes and quantities as determined by the telecommunications company.
- H. Contractor shall be responsible for contacting and coordinating with the telecommunications utility company prior to ordering or installing any telephone entrance equipment and provisions.

2.3. CABLE TELEVISION COMPANY PROVISIONS

- A. The Cable Television Company is Comcast.
- B. Incoming CATV Service:
 - 1. Coordinate incoming CATV service requirements with the cable television company. Provide one (1) 4-inch Schedule 40 PVC conduit underground from the CATV service equipment backboard to the CATV pedestal in the vicinity of the power company's pad-mounted transformers unless otherwise indicated on the Drawings.
 - 2. Extend one (1) 4-inch Schedule 40 underground service conduit to 5'-0" beyond the property line, then cap and stub. Terminate conduits in the exact location and

manner as directed by the CATV company.

- a. Extend one 4-inch empty EMT conduit run concealed, from main CATV demarcation equipment to MDF Room and terminate at MATV/CATV head-end equipment in exact location and manner as required.

2.4. TYPICAL INCOMING SERVICE PROVISIONS

- A. Pull Cords: 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. Utility Holes: Purchase from utility company. Provide as required.
- F. Underground Marking: Provide detectable warning tape over all conduits.
- G. Bends: Minimum 5 foot radius (horizontal) and 36-inch radius (vertical).
- H. Concrete for encasement: As specified in Division 26 Section 260543, “Underground Ducts and Raceways for Electrical Systems”, unless otherwise noted on the Drawings, with air entrainment and pea gravel.
- 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 Cords: Pull cords shall be left in all conduits, after mandrel pull.
- C. Coordination: Coordinate location of telephone and CATV wall spaces, raceways, 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 transformer, pedestal, and utility equipment locations.
- C. Coordinate utility line separation requirements between electric, water, sewer, gas, telephone and CATV.
- D. Contractor shall clear area for all utility cables of rubble, debris, stumps, and other obstructions.

END OF SECTION

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MEDIUM VOLTAGE TRANSFORMERS
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SECTION 26 12 00 - MEDIUM VOLTAGE 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 the following:
 - 1. Liquid-filled pad-mounted distribution transformers.

1.3. SUBMITTALS

- A. Shop Drawings
 - 1. Submit product data under provisions of General Conditions of the Contract and Section 260500, "Common Work Results for Electrical".
 - 2. Include outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, loss data, efficiency at 25, 50, 75 and 100 percent rated load, sound level, tap configurations, insulation system type, and rated temperature rise.
 - 3. Include detailed drawings of any changes to existing installations to suit proposed equipment to be furnished.
 - 4. Include manufacturer's installation instructions.
 - 5. Submit ¼-inch scaled shop drawings indicating transformer(s), equipment pads, clearances, dimensions, existing conditions, and other major components. Shop drawings shall be specific to location being installed.
- B. Factory Certified Tests
 - 1. Factory certified tests shall be performed on the transformer being supplied and the results presented to the Project Manager for approval before shipment. The following factory certified tests shall be performed:
 - a. Insulation resistance tests shall be performed winding-to-winding and winding-to ground.
 - b. A turns ratio test shall be performed between windings at all service tap settings.
 - c. Overpotential test shall be made on all high and low voltage windings to ground.
 - d. Winding resistance tests shall be made for each winding at the in-service tap.
 - e. Verify that the tap settings/changer is at the desired ratio.
 - f. Measure secondary voltage phase-to-phase and phase-to-ground after final energization and prior to loading.
 - g. Verify and/or connect transformer "XO" to ground, load side of "WYE" systems.

1.4. OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of General Conditions of the Contract and Division 01.
- B. Include procedures for cleaning unit, maintaining fluid levels, and replacing components.

1.5. QUALITY ASSURANCE

- A. Manufacturer: Company specializing in distribution transformers with ten years experience.
- B. Comply with the latest requirements of IEEE, ANSI, ASTM, NEMA, and ASA-NEMA Standards.

1.6. DELIVERY, STORAGE, AND HANDLING

- A. Store and protect equipment in a warm, dry location with uniform temperature. Cover ventilating openings to keep out dust.
- B. Handle transformers using only lifting eyes and brackets provided for that purpose. Protect units against entrance of rain, sleet, or snow if handled in inclement weather.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Acceptable Manufacturers: Subject to compliance with requirements, supply equipment from one of the following manufacturers: No other manufacturers are acceptable.
 - 1. Oil-Filled Transformers
 - a. Square D Company
 - b. General Electric
 - c. Cooper Power
 - d. ABB, Inc.

2.2. OIL-FILLED TRANSFORMERS

- A. Furnish and install at the locations indicated on drawings completely metal enclosed, compartmented, oil-filled, pad-mounted distribution transformers.
- B. Equipment shall have the following ratings:
 - 1. Capacity - KVA rating as indicated on the Drawings @ 65 degrees C Rise.
 - 2. Primary Voltage - As indicated on the Drawings.
 - 3. Secondary Voltage: - As indicated on the Drawings.
 - 4. Taps: - Two (2) @ 2-1/2 percent Above and Below Nominal.
 - 5. Phase: - Three.
 - 6. Frequency: - 60 Hertz.

7. B.I.L. - 95 kV.
 8. Insulation - O.I.S.C.
 9. Impedance - As indicated on the Drawings.
- C. The unit shall be constructed for outdoor, fenceless, weatherproof service, and shall be suitable for mounting directly on the concrete foundation pad with high and low voltage cable entrance from below.
- D. Interrupting capacity shall be a minimum of 42,000 amperes symmetrical. Provide low voltage barrier.
- E. The transformer shall be of sealed tank construction and furnished with the following features:
1. Combination drain and sampler valve (minimum 1-inch).
 2. Upper filter press connection.
 3. Liquid level gauge.
 4. Dial thermometer.
 5. Manual tap changer handle.
 6. Pressure relief valve.
 7. Lifting lugs.
 8. Grounding pads.
 9. Jacking lugs.
 10. Tamper-proof handhole on tank.
 11. Diagrammatic nameplate.
 12. Provisions for padlocking and recessed bolting the hinged doors of the air terminal chamber with access to the high voltage section only after opening the low voltage section door.
 13. Non-PCB Certification label.
 14. The front of both compartments shall be removable to allow the transformer to be rolled or skidded into position over conduit stubs. ANSI tank grounding provisions shall be furnished in both compartments.
 15. Filling plug-mounted in the cover.
 16. Tap changer handle.
 17. Vacuum/Pressure Gauge.
 18. Liquid Temperature Gauge.
 19. Winding Temperature Gauge with alarm contacts and control relays.
 20. *WARNING - HIGH VOLTAGE* Label.
- F. The unit shall be constructed of welded steel plate with no exposed boltheads, protrusions, sharp edges, or openings which would permit entrance by other than authorized personnel. The entire assembly shall be cleaned of weld scale, primed, and given a finish coat of "Forest Green", oil-resistance outdoor enamel paint, or other color as selected by the Owner.
- G. The transformer shall be manufactured and tested in accordance with the latest applicable requirements of IEEE, NEMA and ANSI.
- H. Liquid: Oil or less flammable liquid may be used depending on where installed and how the vault is constructed. All oil shall be non-PCB. A permanent label shall be affixed to the tank indicating transformer dielectric fluids contained less than 50 PPM of PCB in

accordance with EPA Requirements at the time of shipment.

- I. HV dead front bushings shall be 600A, either universal wells or one-piece integrated for use with separable connectors. Bushings shall be externally clamped and front removable.
- J. The low voltage bushings ($\leq 600V$) shall be molded polymer, and provided with blade-type spade terminals with NEMA standard hole spacing arranged for vertical take-off. The low voltage neutral shall be an insulated bushing, grounded to the tank by a removable ground strap.
- K. Provide a load break, gang operated, liquid immersed switch rated at 600A that is externally operable from the high voltage compartment through the use of a distribution hot-stick. Switch to be 4-position “sectionalizing” type for use on an extended radial or loop-feed system with feed-from-the-left, feed-from-the-right, isolated-from-either-side, or through-feed to both sides.
- L. Primary Overcurrent Protection: Two fuse system consisting of Bayonet-type, oil-immersed expulsion fuse in series with current-limiting backup fuse mounted inside the transformer under oil. The current limiting fuse should be located as near as practical to the incoming primary bushing, on the source side of the expulsion fuse. The two fuses shall be coordinated so that the expulsion fuse clears low energy faults on the secondary system and the current limiting fuse clears only high energy, includes overload protection, can be provided as an alternate with approval from the Owner. All transformer fusing shall be coordinated with upstream phase overcurrent devices.
- M. Copper windings.
- N. Transformer Start-Up: The transformer will not be started until all tests are complete and turned over to the Owner and the Engineer (2 sets) for review and approval.

PART 3. EXECUTION

3.1. EXAMINATION

- A. Verify field measurements are as shown on Drawings.
- B. Verify that required utilities are available, in proper location and ready for use.
- C. Beginning of installation means installer accepts conditions.

3.2. INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Set transformer plumb and level.
- C. Mount primary surge arresters inside of transformers.
- D. Provide safety labels per NEMA 260.

3.3. EQUIPMENT MOUNTING PADS

- A. Provide concrete equipment mounting pads as required for setting medium voltage transformers. Concrete shall be 3000 psi, 28-day minimum or as specified in Division 03. Refer to detail on electrical drawings for electrical equipment pads.

3.4. FIELD QUALITY CONTROL

- A. Oil-Filled Transformers: Field testing will be performed by independent testing agency provided by the Contractor. Perform testing as required by NETA and as follows:
 - 1. Sample insulating liquid in accordance with ASTM D3613 and perform dissolved gas analysis (DGA) in accordance with ANSI / IEEE and ASTM.
 - 2. Turns ratio tests on the rated voltage connection and on all tap connections.
 - 3. Polarity and phase-relation tests on the rated voltage connection.
 - 4. Power factor tests in accordance with manufacturer's instructions.
 - 5. Dielectric absorption test, winding-winding, and winding-ground.
 - 6. Winding resistance for each winding at nominal tap position.
- B. Any equipment which fails any of the required tests shall be replaced with new, or repaired at Owner's discretion. Equipment with marginal results, as interpreted by the Owner or Engineer, shall also be replaced or repaired at the Owner's discretion.
- C. Check for damage and tight connections prior to energizing transformer.

3.5. ADJUSTING

- A. Adjust transformer primary taps so that secondary voltage is within 1.5 percent of rated voltage.

END OF SECTION

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DIVISION 26 SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS
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SECTION 26 22 00 – LOW-VOLTAGE 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.
- 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 260526, “Grounding and Bonding for Electrical Systems”, for grounding requirements specific to separately derived systems.
 - 3. Division 26 Section 260553, “Identification for Electrical Systems”, for identification materials for labeling transformers, including, but not limited to equipment nameplates.
 - 4. Division 26 Section 260573, “Power System Studies”, for engineering analysis involving transformers specified herein.

1.2. SUMMARY

- A. This Section includes dry-type distribution and high harmonic/non-linear load transformers rated 1000 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. Field Test Reports: Indicate and interpret test results for tests specified in Part 3 of this Section.
- E. Maintenance Data: For transformers to be included in the Operation and Maintenance Manuals specified in Division 01 and Division 26 Section 260500, “Common Work Results for Electrical”.
- F. 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 of this Section.
- 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. 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. 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.

1.7. EXTRA MATERIALS

- A. Touchup Paint: Provide one (1) standard size canister of manufacturer's touch-up paint for every five (5) transformers, finish to match standard enclosure finish as specified herein. Furnish at least one (1) canister of touch-up paint.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, supply equipment from one of the following manufacturers: No other manufacturers are acceptable.
 1. Square D Company. (Basis of Design)
 2. Eaton/Cutler-Hammer.

3. Acme Electric Corp.; Transformer Division.
4. General Electric (GE)
5. Hammond Power Solutions (HPS)
6. Powersmiths.

2.2. TRANSFORMERS, GENERAL REQUIREMENTS

- A. Description: 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 aluminum windings without splices, except for taps.
- D. Coil Conductors: Individually insulate secondary conductors and arrange to minimize hysteresis and eddy current losses at harmonic frequencies.
- E. Internal Coil Connections: Brazed or pressure type.
- F. Enclosure: Class complies with NEMA 250 for the environment in which installed. Comply with NEMA ST 20.
- G. Nameplates: Include transformer connection data and overload capacity based on rated allowable temperature rise.
- H. Basic Impulse Level: 10 kV for transformers less than 300 kVA.

2.3. ENERGY EFFICIENT GENERAL PURPOSE TRANSFORMERS

- A. Description
 1. Dry-type distribution transformers for general loads, single and/or three-phase, with primary and secondary voltages of 600 V and less and capacity ratings 15kVA through 750kVA.
- B. Standards
 1. Transformers 750kVA and smaller shall be listed by Underwriters Laboratories.
 2. Conform to the requirements of ANSI/NFPA 70.
 3. Transformers are to be manufactured and tested in accordance with NEMA ST20 and UL 1561.
 4. Transformers shall be low loss type with minimum efficiencies per US Department of Energy (DOE) 2016 Standards, as defined in the Code of Federal Regulations, 10 CFR 431.192.
- C. Manufacturers
 1. Approved manufacturers shall be registered firms in accordance with ISO 9001 SIC3612 (US); which is the design and manufacture of low voltage dry type power, distribution and specialty transformers.

D. Ratings Information

1. All insulating materials are to exceed NEMA ST20 standards and be rated for 220 degrees C UL component recognized insulation system.
2. Transformers 15kVA and larger shall be 150 degrees C temperature rise above 40 degrees C ambient. Transformers 25kVA and larger shall have a minimum of 4 – 2.5% full capacity primary taps. Exact voltages and taps to be as designated on the plans or the transformer schedule.
3. The maximum temperature of the top of the enclosure shall not exceed 50 degrees C rise above a 40 degrees C ambient.

E. Construction

1. Transformer coils shall be of continuous wound construction and shall be impregnated with non-hygroscopic, thermosetting varnish.
2. All cores to be constructed with low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturated point to prevent core overheating. Cores for transformers greater than 500kVA shall be clamped utilizing insulated bolts through the core laminations to ensure proper pressure throughout the length of the core. The completed core and coil shall be bolted to the base of the enclosure, but isolated by means of rubber vibration-absorbing mounts. There shall be no metal-to-metal contact between the core and coil and the enclosure except for a flexible safety ground strap. Sound isolation systems requiring the complete removal of all fastening devices will not be acceptable.
3. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.
4. The transformer enclosures shall be ventilated and be fabricated of heavy gauge, sheet steel construction. The entire enclosure shall be finished utilizing a continuous process consisting of degreasing, cleaning and phosphatizing, followed by electrostatic deposition of polymer polyester powder coating and baking cycle to provide uniform coating of all edges and surfaces. The coating shall be UL recognized for outdoor use. The coating color shall be ANSI 49.

F. Sound Levels

1. Sound levels shall be warranted by the manufacturer not to exceed the following:
15 to 50 KVA - 45dB; 51 to 150kVA – 50dB; 151 to 300kVA – 55dB; 301 to 500kVA – 60dB; 501 to 700kVA – 62dB; 701 to 1000kVA – 64dB; 1001 to 1500kVA – 65dB; 1501 to 2000kVA – 66dB

2.4. HIGH HARMONIC LOAD (K-RATED) TRANSFORMERS

A. Description

1. Dry type distribution transformers for non-linear loads, single and/or three phase, primary and secondary voltage of 600V and less and capacity ratings of 15kVA through 750kVA.

B. Standards

1. Transformers 750kVA and smaller shall be listed by Underwriters Laboratories.
2. Conform to the requirements of ANSI/NFPA 70.
3. Transformers are to be manufactured and tested in accordance with NEMA ST20 and UL1561.
4. Transformers shall be low loss type with minimum efficiencies per US Department of Energy (DOE) 2016 Standards, as defined in the Code of Federal Regulations, 10 CFR 431.192.

C. Manufacturers

1. Approved manufacturers shall be registered firms in accordance with ISO9001 SIC 3612 (US); which is the design and manufacture of low voltage dry type power, distribution and specialty transformers.

D. Ratings Information

1. All insulating materials are to exceed NEMA ST20 standards and be rated for 220 degrees C UL component recognized insulation system.
2. Neither the primary nor the secondary temperature shall exceed 220 degree C at any point in the coils while carrying their full rating of non-sinusoidal load. Transformers are to be UL listed and labeled for [K-9][K-13] as defined as the sum of fundamental and harmonic 1 h per UL 1561. Transformers evaluated by the UL K factor evaluation shall be listed for 150 degrees C average temperature rise.
3. K factor rated transformers shall have an impedance range of 3% to 5% and shall have a minimum reactance of 2% in order to help reduce neutral current when supplying loads with large amounts of third harmonic current.
4. Transformers 15kVA and larger shall have a minimum of 6 – 2.5% full capacity primary taps for 480V primaries and a minimum of 2 – 5% fully capacity taps for 208V primaries. Exact voltage and taps to be as designated on the plans or the transformer schedule.
5. The maximum temperature of the top of the enclosure shall not exceed 50 degrees C rise above a 40 degrees C ambient.

E. Construction

1. Transformer coils shall be of continuous wound construction and shall be impregnated with non-hygroscopic, thermosetting varnish.
2. All cores to be constructed with low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point to prevent core overheating. The core laminations shall be clamped together with steel angles. The completed core and coil shall be bolted to the base of the enclosure but isolated by means of rubber vibration absorbing mounts. There shall be no metal-to-metal contact between the core and coil and the enclosure except for a flexible safety ground strap. Sound isolation systems requiring the complete removal of all fastening devices will not be acceptable.
3. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.
4. The transformer enclosures shall be ventilated and be fabricated of heavy gauge, sheet steel construction. The entire enclosure shall be finished utilizing a continuous process consisting of degreasing, cleaning and phosphatizing, followed

by electrostatic deposition of polymer polyester powder coating and baking cycle to provide uniform coating of all edges and surfaces. The coating shall be UL recognized for outdoor use. The coating color shall be ANSI 49.

5. Transformers shall be supplied with quality, full width electrostatic shields resulting in a maximum effective coupling capacitance between primary and secondary of 33 picofarads. With transformers connected under normal, loaded operating conditions, the attenuation of line noise and transients shall equal or exceed the following limits:
 - a. Common Mode: 0 to 1.5kHz – 120dB; 1.5kHz to 10kHz – 90dB; 10kHz to 100kHz – 65dB; 100kHz to 1MHz – 40dB
 - b. Transformer Mode: 1.5kHz to 10kHz – 52dB; 10kHz to 100kHz – 30dB; 100kHz to 1MHz 30dB
6. Sound Levels
 - a. Sound levels shall be warranted by the manufacturer not to exceed the following:
 - i. 15 to 50kVA – 45dB; 51 to 150kVA – 50dB; 151 to 300kVA – 55dB; 301 to 500kVA – 60dB; 501 to 700kVA – 62dB; 701 to 1000kVA – 64dB.

2.5. FINISHES

- A. Indoor Units: Manufacturer's standard paint over corrosion-resistant pretreatment and primer.
- B. Outdoor Units: Comply with ANSI C57.12.28.

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, "Identification for Electrical Systems".
- 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, as indicated on the Drawings, 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. Securely anchor transformers to concrete pad for floor-mounted transformers.

3. Provide working clearances in conformance with NFPA 70.
 4. Provide both, 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 structure.
- I. Provide minimum 4-inch high concrete pad for floor-mounted transformers. Refer to Division 26 Section 260500, “Common Work Results for Electrical”, for installation requirements.
- J. Verify mounting supports are properly sized and located.

3.2. GROUNDING

- A. Separately Derived Systems: Comply with requirements of National Electrical Code Article 250.30 – The grounding electrode conductor (GEC) connection shall be made at the source of the separately derived system (i.e. the transformer) in the transformer enclosure, where the system bonding jumper shall also be installed. Provide supply-side bonding jumper from transformer to first disconnecting means or overcurrent device after the transformer.
- B. Comply with Division 26 Section 260526, “Grounding and Bonding for Electrical Systems”, 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. Visual and Mechanical Inspection:
1. Inspect for defects and physical damage, labeling, and compliance with requirements of drawings and schedules.
 2. Clean transformers using Manufacturer’s approved methods and materials.
 3. Verify that transformer nameplates are installed and accurate.
 4. Verify that transformer phase identification nameplates are installed.
 5. Verify that transformer arc flash hazard labels are installed.
 6. Check mounting, area clearances, and alignment and fit of components.
 7. Check tightness of bolted electrical connections with calibrated torque wrench.
 8. Refer to manufacturer’s instructions for proper torque values.
 9. Verify that neutral bar is bonded to ground bar with appropriately sized bonding jumper.
 10. Verify that equipment ground bar is bonded to transformer enclosure. Securing ground bar to vent opening is not acceptable.

- B. Transformer Electrical Tests: Include the following minimum inspections and tests according to manufacturer's written instructions to ensure transformer is operational within industry and manufacturer's tolerances, is installed according to the Contract Documents, and is suitable for energizing. Comply with IEEE C57.12.91 for test methods and data correction factors.
1. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing. 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.
 2. 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.
 3. 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.
 4. Insulation Resistance Testing: Perform megohm meter tests of primary and secondary winding to winding and winding to ground, as follows:
 - a. Minimum Test Voltage: 1000 Vdc.
 - 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.
 - e. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - f. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
 5. Infrared Scanning: Perform an infrared scan of all electrical connections in each transformer, as follows:
 - a. Remove equipment covers so terminations are accessible to scanner.
 - b. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values.
 - c. Provide calibration record for device.
 - d. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - e. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
 6. Test Labeling: On satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.

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.

3.5. ADJUSTING

- A. Record transformer secondary voltages at each transformer for at least 48 hours of typical occupancy. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare a written test report recording output voltages and tap settings.
- C. Occupancy Adjustments: When requested within twelve (12) months of Substantial Completion, provide on-site assistance in readjusting transformer tap settings to suit actual occupied conditions. Provide up to two (2) visits to the project site for this purpose at no additional cost. Make voltage recordings at equipment/outlets selected by Owner, and record transformer secondary voltages for up to 48 hours.

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.
- 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, “Identification for Electrical Systems”, for identification materials for labeling switchboards, including, but not limited to equipment nameplates.
 - 3. Division 26 Section 260573, “Power System Studies”, for engineering analysis involving switchboards specified herein.
 - 4. Division 26 Section 264113, “Lightning Protection for Structures”, for requirements for lightning protection systems specific to surge protective devices in switchboards as specified herein.
 - 5. Division 23 Section 230900, “Instrumentation and Controls of HVAC and Plumbing Systems” for interface between electricity meters and building automation system.

1.2. SUMMARY

- A. This Section includes service and distribution switchboards rated 600 volts and less.
- B. Provide design and engineering, labor, material, equipment, related services and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for switchboards as required for the complete performance of the work, and as shown on the Drawings and as specified herein.
- C. Switchboards shall be fully rated for the AIC identified on the switchboard schedules on the Contract Drawings.
- D. Minimum short-circuit current ratings for switchboards shall be verified by short circuit analysis specified under Division 26 Section 260573, “Power System Studies”, prior to ordering equipment.

1.3. REFERENCES

- A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
- B. American Society of Testing Materials (ASTM):
 - 1. ASTM E 329, “Standard Specification for Agencies Engaged in the Testing and/or

inspection of Materials Used in Construction.”

- C. Federal Specifications (FS):
 - 1. FS W-C-375, “Circuit Breakers, Molded Case, Branch Circuit and Service.”
- D. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. ANSI/IEEE C57.13, “Standard Requirements for Instrument Transformers.”
- E. International Electrical Testing Association (NETA):
 - 1. NETA ATS, “Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.”
- F. International Organization for Standardization (ISO):
 - 1. ISO 9001, “Quality Management Systems – Requirements.”
- G. National Electrical Contractors Association (NECA):
 - 1. NECA 400, “Standard for Installing and Maintaining Switchboards.”
- H. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA KS 1, “Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).”
 - 2. NEMA PB 2, “Deadfront Distribution Switchboards.”
 - 3. NEMA PB 2.1, “General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less.”
 - 4. NEMA PB 2.2, “Application Guide for Ground Fault Protective Devices.”
- I. National Fire Protection Association (NFPA):
 - a. NFPA 70, “National Electrical Code.”
 - b. NFPA 70B, “Electrical Equipment Maintenance.”
 - c. NFPA 70E, “Standard for Electrical Safety in the Workplace.”
- J. Underwriters Laboratories, Inc. (UL):
 - 1. UL 98, “Standard for Enclosed and Dead-Front Switches.”
 - 2. UL 489, “Standard for Molded-Case Circuit Breakers and Circuit Breaker Enclosures.”
 - 3. UL 891, “Standard for Dead-Front Switchboards.”
 - 4. UL 943, “Standard for Ground-Fault Circuit Interrupters.”
 - 5. UL 1449, “Standard for Surge Protective Devices.”

1.4. SUBMITTALS

- A. Product Data: Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications.

1. Submit product data for each type of switchboard, overcurrent protective device, surge protective device, ground fault protector, accessory, and component indicated.
 2. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: Include the following for each switchboard:
1. Dimensioned Plans: Show dimensioned front and side enclosure plans and elevations, including required clearances and service space.
 2. Component and Device Lists: Show tabulations of installed devices, features and voltage rating.
 3. Single-Line Diagram: Show main- and branch-bus current ratings and short-time and short-circuit ratings of switchboards.
 4. Wiring Diagrams: Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer-installed and field-installed wiring, and between components provided by the manufacturer and those provided by others.
 5. Nameplate Legends: Submit sample equipment nameplates for switchboards and for individually-mounted and/or group-mounted branch devices.
- C. Quality Control Submittals: Submit field quality control test reports certified by testing agency.
- D. Contract Closeout Submittals:
1. Operation and Maintenance Data: Submit operation and maintenance data for switchboards to include in operation and maintenance manuals specified in Division 01.
 2. Warranty Data: Submit manufacturer's standard warranty documents.
 3. Switchboard Circuit Directories: For installation in switchboards. Submit final versions after load balancing.
 4. Project Record Data: Record actual locations of switchboards, indicating actual feeder circuit arrangement.

1.5. QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of switchboards of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 20 years. The manufacturer shall be ISO 9001 certified and shall be designed to internationally accepted standards.
- B. Installer Qualifications: Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing switchboards similar in type and scope to that required for this Project.
- C. Testing Agency Qualifications: In addition to the 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 National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3 of this Section.
- D. 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.

1.6. DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and lot number, if any.
- B. Deliver in shipping splits of lengths that can be moved past obstructions in delivery path.
- C. Store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.
- D. Store so condensation will not occur on or in switchboards. Provide temporary heaters as required to avoid condensation.
- E. Handle switchboards according to NEMA PB 2.1. Use only factory-installed lifting provisions.

1.7. PROJECT CONDITIONS

- A. Environmental Requirements: Do not install switchboards until space is enclosed and weatherproof, wet work space is completely and nominally dry, overhead work is complete, and ambient temperature and humidity conditions are and will be continuously maintained at values near those indicated for final occupancy.
- B. Verify Dimensions: Verify NEC and all Code clearance requirements by field measurements. Locate switchboard to meet installation tolerances.
- C. Determine suitable path for moving switchboard into place considering Project conditions.
- D. Revise locations and elevations from those indicated as required to suit Project conditions.

1.8. 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. 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.

1.9. EXTRA MATERIALS

- A. Keys: Provide two (2) spares for each type of switchboard lock.
- B. Touchup Paint: Provide one (1) standard size canister of manufacturer's touch-up paint for each switchboard, finish to match standard enclosure finish as specified herein. Furnish at least one (1) canister of touch-up paint.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Acceptable Manufacturers: Subject to compliance with requirements, supply equipment from one of the following manufacturers: No other manufacturers are acceptable.
 - 1. Square D Company. (Basis of Design)
 - 2. Eaton Corporation; & Cutler-Hammer Products.
 - 3. Siemens Energy & Automation Inc.
 - 4. General Electric (GE)

2.2. MANUFACTURED UNITS

- A. Front-Accessible Switchboard: Front and rear aligned, with features as follows:
 - 1. Main Device: Fixed, individually-mounted.
 - 2. Branch Devices: Fixed, panel-mounted plug-on devices rated 1200 amperes and less.
- B. Ratings: Provide nominal system voltage, continuous main-bus amperage, and short-circuit current ratings as indicated.

2.3. FABRICATION AND FEATURES

- A. Enclosure: Provide steel enclosure, in compliance with UL 891, Type as indicated on the Drawings, unless otherwise indicated to meet environmental conditions at installed location as indicated below:
 - 1. Dry, Interior Locations: NEMA 1
- B. Enclosures
 - 1. Type 1 Enclosures
 - a. Boxes shall be hot zinc dipped galvanized steel constructed in accordance with UL 50 requirements. Zinc-coated galvanized steel will not be acceptable.
 - b. Boxes shall have removable blank end walls and interior mounting studs. Interior support bracket shall be provided for ease of interior installation.
 - c. Trim front steel shall meet strength and rigidity requirements per UL 50

- standards. Shall have an ANSI 49 medium gray enamel electrodeposited over cleaned phosphatized steel.
- d. Trim fronts shall be 4-piece surface and shall have rounded corners and edges free of burrs.
- C. Barriers: Adjacent switchboard sections shall be isolated by means of physical barriers. Barriers shall permit checking of bus bolt tightness.
- D. Hinged Front Panels: All front covers shall be screw removable with a single tool and all doors shall be hinged with removable hinge pins.
- E. Buses and Connections: Three phase, four wire, unless otherwise indicated.
1. Bus Composition: Silver-plated copper, hard-drawn, minimum of 98 percent conductivity. Plating shall be applied continuously to bus work. The switchboard bussing shall be of sufficient cross-sectional area to meet UL 891 temperature rise requirements. The phase and neutral through-bus shall have an ampacity as shown on the Drawings. Coordinate bus short circuit rating with available fault current. Size in accordance with NEMA PB 2. Tapered buses shall not be acceptable.
 2. Group-Mounted Feeder Vertical Bus Stack:
 - a. Bus stack shall be capable of mounting feeder breakers with different frame sizes and number of poles across from one another on the bus stack.
 - b. Non-conducting surface films shall be removed during circuit breaker installation by a wiping action of the circuit breaker jaws.
 - c. The design of the circuit breaker jaws and bus stack shall create blow-on forces under fault conditions.
 - d. Bolted lap joint connections for feeder breakers shall not be allowed for group-mounted feeders.
 3. Ground Bus:
 - a. 1/4-by-2-inch minimum size, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder- and branch-circuit ground conductors.
 - b. Provide ground lug and ground bus firmly secured to each vertical section structure and shall extend the entire length of the switchboard.
 4. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity the entire length of the switchboard main and distribution sections. Provide for future extensions from both ends.
 5. Neutral Buses: 100 percent of the ampacity of the phase buses, except as indicated, and equipped with approved pressure connectors for outgoing circuit neutral cables.
- F. Future Devices: All unused spaces provided, unless otherwise indicated, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware. Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit breaker compartment.
- G. Expansion Provisions: The switchboard shall be designed for future expansion, with full

size horizontal bussing throughout and extension stub-outs.

2.4. OVERCURRENT PROTECTIVE DEVICES

- A. Overcurrent protective devices include, but are not limited to, the following:
 - 1. Electronic trip circuit breakers.
 - 2. Thermal magnetic circuit breakers.
- B. Molded-Case Circuit Breaker Features and Accessories:
 - 1. Characteristics: Frame size, trip rating, number of poles, and auxiliary devices as indicated and interrupting capacity rating to meet available fault current.
 - 2. Lugs: Mechanical style, suitable for quantity, size/gauge, and material of conductors indicated.
 - 3. Application Listing: Appropriate for application, including switching fluorescent lighting loads (Type SWD) or heating, air-conditioning, and refrigerating equipment (Type HACR).
 - 4. Handle Padlock Attachment: All circuit breakers in switchboards shall be equipped with fixed handle padlock attachment to allow padlocking the circuit breaker in the ON or OFF position.
 - 5. Ground Fault Protection: Integral to circuit breaker with adjustable pickup and time delay settings, push-to-test feature, and ground-fault indicator.
 - 6. Shunt Trip: 120 volt trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.

2.5. INCOMING MAIN SECTION DEVICE

- A. Main Circuit Breaker(s).
 - 1. Electronic trip, molded case, [80%] [100%] rated circuit breaker(s) with Micrologic® interchangeable ammeter trip unit and the following time/current response adjustments:
 - a. Long Time Pickup
 - b. Long Time Delay
 - c. Short Time Pickup
 - d. Short Time Delay
 - e. Instantaneous Settings
 - 2. Main circuit breakers rated 1,000 amperes or more shall be equipped with integral ground-fault protection with the following adjustments:
 - a. Ground Fault Pickup
 - b. Ground Fault Delay
 - 3. Circuit breakers where the highest continuous current trip setting can be adjusted to 1200A or higher, shall be equipped with arc energy reducing maintenance settings, in compliance with National Electrical Code Article 240.87.
 - 4. All adjustments shall have discrete settings (fully adjustable) and shall be independent of all other adjustments.

5. Circuit breaker trip system shall be microprocessor-based true RMS sensing designed with sensing accuracy through the thirteenth (13th) harmonic.
6. Sensor ampere ratings shall be as indicated herein or on the Drawings.
7. Local visual trip indication for overload, short circuit [and ground fault] trip occurrences.
8. Long time pickup indication shall signal when loading approaches or exceeds the adjustable ampere rating of the circuit breaker.
9. Communications capabilities for remote monitoring of circuit breaker trip system, to include phase and ground fault currents, pre-trip alarm indication, switch settings, and trip history information shall be provided.
10. Provide phase loss/failure relay that will trip main circuit breaker on loss of any single phase for switchboards used as service entrance equipment. Relays that operate on loss of all three phases are not acceptable.
11. Basis of Design: Square D Company, Micrologic® Power Trip Units

2.6. DISTRIBUTION SECTION DEVICES – GROUP MOUNTED CIRCUIT BREAKERS

A. General Requirements

1. Circuit breaker(s) shall be group mounted plug-on with mechanical restraint on a common pan or rail assembly.
2. The interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulator laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.
3. Circuit breaker(s) equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breaker(s) shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners. Circuit breaker(s) of different frame sizes shall be capable of being mounted across from each other.
4. Line side circuit breaker connections are to be jaw type.
5. Furnish thermal magnetic molded case circuit breakers for 250A frames and below.
6. All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.

B. Electronic Trip Molded Case Circuit Breakers

1. Electronic trip, molded case, 80% rated circuit breaker(s) with Micrologic® interchangeable ammeter trip unit and the following time/current response adjustments:
 - a. Long Time Pickup
 - b. Long Time Delay
 - c. Short Time Pickup
 - d. Short Time Delay
 - e. Instantaneous Settings
2. Circuit breakers where the highest continuous current trip setting can be adjusted to 1200A or higher, shall be equipped with arc energy reducing maintenance setting, in compliance with National Electrical Code Article 240.87.
3. All adjustments shall have discrete settings (fully adjustable) and shall be

independent of all other adjustments.

4. Circuit breaker trip system shall be micro-processor based true RMS sensing designed with sensing accuracy through the thirteenth (13th) harmonic.
5. Sensor ampere trip ratings shall be as indicated on the Drawings.
6. Local visual trip indication for overload, short circuit and ground fault trip occurrences.
7. Long time pickup indication to signal when loading approaches or exceeds the adjustable ampere rating of the circuit breaker shall be provided.

C. Thermal Magnetic Circuit Breakers

1. Molded case circuit breakers shall have integral thermal and instantaneous magnetic trip in each pole.
2. Ampere ratings shall be as shown on the Drawings.
3. Ampere interrupting capacity ratings shall be as shown on the Contact Drawings, but not less than 35,000 AIC RMS symmetrical amperes at rated voltage.

2.7. SURGE PROTECTION DEVICES

- A. Description: Surge Protection 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
 2. Eaton Corporation; Cutler-Hammer Products
 3. 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. 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 242.

- 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 over-temperature 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. Switchboards: 320kA
- 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:

System Voltage	L-N	L-G	L-L	N-G
480Y/277V	1200V	1200V	1800V	1200V

- L. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV):

System Voltage	MCOV	Allowable System Voltage Fluctuation (%)
480Y/277V	320V	15%

- 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 and shall include unlimited replacement of suppression modules within the warranty period. Warranty shall be the responsibility of the electrical distribution equipment manufacturer and shall be supported by their respective field service division.

2.8. 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 one (1) MOD-BUS serial port and two (2) ethernet ports. One (1) ethernet port shall be interfaced with building's ATC system, and one (1) ethernet port shall be interfaced with building LAN to provide e-mail on alarm to the Owner.
 - 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.

2.9. INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, ANSI/IEEE C57.13.
- B. Potential Transformers: Secondary voltage rating of 120 volts and NEMA accuracy class of 0.3 with burdens of W, X, and Y.

- C. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.

2.10. CONTROL POWER

- A. Control Circuits: 120 volts, supplied through secondary disconnecting devices from control power transformer.
- B. Control Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
- C. Control Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- D. Control Wiring: Factory-installed, with bundling, lacing, and protection included. Provide flexible conductors for 8 AWG and smaller, for conductors across hinges, and for conductors with interconnections between shipping units.

2.11. IDENTIFICATION

- A. Compartment Nameplates: Engraved laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws or suitable adhesive.
- B. 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.
- C. Switchboards used as service-entrance equipment shall be labeled as the same.
- D. Refer to Division 26 Section 260553, "Identification for Electrical Systems", for additional information.

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.

3.2. INSTALLATION

- A. Install switchboards level and plumb as indicated, according to manufacturer's written instructions and NEMA PB 2.1.
- B. Support switchboards on concrete housekeeping pads. Refer to Division 26 Section,

“Common Work Results for Electrical” for requirements for housekeeping pads.

- 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 overcurrent protective devices, surge protective devices, and instrumentation.
- F. Do not energize or connect service-entrance equipment and switchboards to their sources until surge protective devices are properly installed and connected.

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. Provide interface between digital electricity meter and building ATC system. Coordinate work with Division 23 Contractor. Provide factory assistance with mapping out any data points with Division 23 Contractor.
- D. Provide network connection between digital electricity meter and building LAN. Coordinate work with Division 27 Contractor and/or Owner. Provide factory assistance with setting up e-mail notifications for alarms, data logging, etc.

3.4. IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section 260553, “Identification for Electrical Systems”.
- B. Label each switchboard compartment with nameplates as specified herein.
- 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. 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 switchboard schedules.
 2. Clean devices using Manufacturer's approved methods and materials.
 3. Verify that switchboard nameplates are installed and accurate. This applies to main nameplate as well as nameplates for distribution section devices.
 4. Verify that switchboard phase identification nameplates are installed.
 5. Verify that switchboard arc flash hazard labels are installed.
 6. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
 7. Check switchboard mounting, area clearances, and alignment and fit of components.
 8. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
 9. Perform visual and mechanical inspection and related work for over-current protective devices.
 10. Verify that all neutral conductors are bonded to the system ground at the service-entrance prior to installation of the surge protective device.
 11. Verify that neutral-ground bonds do not exist at locations that are not service entrances or separately derived power sources.
 12. Verify that field-adjustable circuit breaker trip settings are adjusted as recommended in coordination study provided under Division 26 Section 260573, "Power System Studies".
- B. Switchboard Electrical Testing: After installing switchboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements
1. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing. 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.
 2. 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.
 3. Inspect bolted connections for tightness according to manufacturer's published torque values or, if not available, those specified in UL 486A and UL 486B.
 4. 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.
 5. Make continuity tests of each circuit. Refer to Division 26 Section 260519, "Low-Voltage Electrical Power Conductors and Cables", for testing specific to feeder conductors.
 6. Perform ground resistance test on system and equipment ground connections
 7. Test main and sub-feed over-current protective devices.
 8. Test ground fault devices in accordance with NETA ATS 7.14.
 9. Test phase loss relay(s) at service-entrance equipment to verify that phase loss relays are fully operational.
 10. NETA Testing:
 - a. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Sections 7.1, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate for all devices rated 100-amperes and larger.

- b. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - c. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
11. Insulation Resistance Testing: Perform megohm meter tests of each bus section phase-to-phase and phase-to ground, as follows:
- a. Minimum Test Voltage: 1000 Vdc for 480V switchboards.
 - b. Minimum Insulation Resistance: 100 megohms.
 - c. Duration of Each Test: 1 minute.
 - d. Temperature Correction: Correct results for test temperature deviation from 20 degrees C standard.
 - e. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - f. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
12. Infrared Scanning: Perform an infrared scan of all electrical connections in each switchboard, as follows:
- a. Remove equipment covers so terminations are accessible to scanner.
 - b. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values.
 - c. Provide calibration record for device.
 - d. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - e. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
13. Perform all other manufacturer specific tests as indicated in manufacturer's literature.
14. Test Labeling: On satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.
15. Submit all test reports to the Architect for review and approval.
16. Provide copy of all test reports in the O&M manual.

3.6. ADJUSTING

- A. Set field-adjustable circuit breaker settings as indicated in coordination study provided under Division 26 Section 260573, "Power System Studies".

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. Provide final protection and maintain conditions in a manner that shall ensure that the switchboard(s) shall be without damage at time of Substantial Completion.

3.9. DEMONSTRATION AND TRAINING

- A. Provide a minimum of four (4) hours of training and demonstration of switchboard operations, settings, adjustment, and maintenance.
- B. Topics to be covered include, but are not limited to, the following:
 - 1. Extracting recorded data from electricity meter.
 - 2. Operation of electricity meter.
 - 3. Charging/Setting up e-mail address for alarms/notifications from electricity meter.
 - 4. Operation of electronic trip circuit breakers.
 - 5. Operation of arc energy reduction maintenance switches.

END OF SECTION

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.
- 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, “Identification for Electrical Systems”, for identification materials for labeling panelboards, including, but not limited to equipment nameplates.
 - 3. Division 26 Section 260573, “Power System Studies”, for engineering analysis involving panelboards specified herein, including but not limited to short-circuit analysis.
 - 4. Division 26 Section 262417, “Fusible Panelboards”, for fusible distribution and branch circuit panelboards rated 600V and less serving emergency and/or legally required power supply systems.
 - 5. Division 26 Section 262418, “Load Centers”, for requirements for load centers to be furnished with engine generators.
 - 6. Division 26 Section 264113, “Lightning Protection for Structures”, for requirements for lightning protection systems specific to surge protection devices in panelboards as specified herein.

1.2. ALTERNATES

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

1.3. SUMMARY

- A. This Section includes lighting and power panelboards and associated auxiliary equipment rated 600 V and less.
- B. Provide design and engineering, labor, material, equipment, related services and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for panelboards as required for the complete performance of the work, and as shown on the Drawings and as specified herein.
- C. Panelboards shall be fully rated for the AIC identified on the panelboard schedules on the Contract Drawings. Panelboards shall be tested, listed, and labeled for the available short circuit current.
- D. Minimum short-circuit current ratings for panelboards shall be verified by short circuit analysis specified under Division 26 Section 260573, “Power System Studies”, prior to ordering equipment.

1.4. REFERENCES

- A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
- B. American Society of Testing Materials (ASTM):
 - 1. ASTM E 329, “Standard Specification for Agencies Engaged in the Testing and/or inspection of Materials Used in Construction.”
- C. Federal Specifications (FS):
 - 1. FS W-C-375, “Circuit Breakers, Molded Case, Branch Circuit and Service.”
- D. International Electrical Testing Association (NETA):
 - 1. NETA ATS, “Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.”
- E. International Organization for Standardization (ISO):
 - 1. ISO 9001, “Quality Management Systems – Requirements.”
- F. National Electrical Contractors Association (NECA):
 - 1. NECA 407, “Standard for Installing and Maintaining Panelboards.”
- G. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA PB 1, “Panelboards.”
 - 2. NEMA PB 1.1, “General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.”
 - 3. NEMA PB 1.2, “Application Guide for Ground Fault Protective Devices.”
- H. National Fire Protection Association (NFPA):
 - 1. NFPA 70, “National Electrical Code.”
 - 2. NFPA 70B, “Electrical Equipment Maintenance.”
 - 3. NFPA 70E, “Standard for Electrical Safety in the Workplace.”
- I. Underwriters Laboratories, Inc. (UL):
 - 1. UL 50, “Standard for Enclosures for Electrical Equipment.”
 - 2. UL 67, “Standard for Panelboards.”
 - 3. UL 489, “Standard for Molded-Case Circuit Breakers and Circuit Breaker Enclosures.”
 - 4. UL 943, “Standard for Ground-Fault Circuit Interrupters.”
 - 5. UL 1449, “Standard for Surge Protective Devices.”

1.5. SUBMITTALS

- A. Product Data: Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications.
 - 1. Submit product data for each type of panelboard, overcurrent protective device, surge protective device, ground circuit interceptor, accessory, and component indicated.
 - 2. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes of individual protective devices and auxiliary components.
- B. Shop Drawings: Include the following for each panelboard:
 - 1. Dimensioned Plans: Show dimensioned enclosure plans and elevations, including required clearances and service space.
 - 2. Component and Device Lists: Show tabulations of installed devices, features and voltage rating.
 - 3. Single-Line Diagram: Show main- and branch-bus current ratings and short-time and short-circuit ratings of panelboards.
 - 4. Wiring Diagrams: Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer-installed and field-installed wiring, and between components provided by the manufacturer and those provided by others.
 - 5. Nameplate Legends: Submit sample equipment nameplates for panelboards.
- C. Quality Control Submittals: Submit field quality control test reports certified by testing agency.
- D. Contract Closeout Submittals:
 - 1. Operation and Maintenance Data: Submit operation and maintenance data for panelboards to include in operation and maintenance manuals specified in Division 01.
 - 2. Warranty Data: Submit manufacturer's standard warranty documents.
 - 3. Panelboard Circuit Directories: For installation in panelboards. Submit final versions in operation and maintenance manuals.
 - 4. Project Record Data: Record actual locations of panelboards, indicating actual branch circuit arrangement.

1.6. QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of panelboards of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 20 years. The manufacturer shall be ISO 9001 certified and shall be designed to internationally accepted standards.
- B. Installer Qualifications: Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing panelboards similar in type and scope to that required for this Project.

- C. Testing Agency Qualifications: In addition to the 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 National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3 of this Section.
- D. 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.

1.7. DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and lot number, if any.
- B. Store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.
- C. Store so condensation will not occur on or in panelboards. Provide temporary heaters as required to avoid condensation.
- D. Handle panelboards according to NEMA PB 1.1. Use only factory-installed lifting provisions.

1.8. PROJECT CONDITIONS

- A. Environmental Requirements: Do not install panelboards until space is enclosed and weatherproof, wet work space is completely and nominally dry, overhead work is complete, and ambient temperature and humidity conditions are and will be continuously maintained at values near those indicated for final occupancy.
- B. Verify Dimensions: Verify NEC and all Code clearance requirements by field measurements. Locate panelboards to meet installation tolerances.
- C. Determine suitable path for moving panelboard(s) into place considering Project conditions.
- D. Revise locations and elevations from those indicated as required to suit Project conditions.

1.9. 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. 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.

1.10. EXTRA MATERIALS

- A. Keys: Provide two (2) spares of each type of panelboard cabinet lock.
- B. Touchup Paint: Provide one (1) standard size canisters of manufacturer's touch-up paint for every ten (10) panelboards, finish to match standard enclosure finish as specified herein. Furnish at least one (1) canister of touch-up paint.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, supply equipment from one of the following manufacturers; no other manufacturers are acceptable:
 - 1. Square D Company. (Basis of Design)
 - 2. Eaton Corp.; Cutler-Hammer Products.
 - 3. General Electric (GE)
 - 4. Siemens Energy & Automation Inc.

2.2. FABRICATION AND FEATURES

- A. Enclosures: Provide steel enclosures, in compliance with NEMA PB1, suitable for flush- or surface-mounting as indicated on the Drawings. Type as indicated on the Drawings, unless otherwise indicated to meet environmental conditions at installed location as indicated below:
 - 1. Dry, Interior Locations: NEMA 1
 - 2. Damp, Wet Locations: NEMA 3R
- B. NEMA 1 enclosures shall be surface or flush mount as indicated in associated schedules or drawings. NEMA 3R enclosures shall be surface mount only.
- C. Enclosure Finish for Indoor Units: A minimum of one (1) coat of factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- D. Front: Secured to box with concealed trim clamps, unless otherwise indicated. Front for surface-mounted panelboards shall be same dimensions as box. Fronts for flush-mounted panelboards shall overlap box, unless otherwise indicated.
- E. Panelboard trim shall be dead-front construction covering all energized parts.
- F. Buses and Connections: Three phase, four wire, unless otherwise indicated.

1. Bus Composition: Silver-plated or tin-plated copper, hard-drawn, minimum of 98 percent conductivity. Plating shall be applied continuously to bus work. The panelboard bussing shall be of sufficient cross-sectional area to meet UL 67 temperature rise requirements. The phase and neutral through-bus shall have an ampacity as shown on the Drawings. Coordinate bus short circuit rating with available fault current. Size in accordance with NEMA PB 1.
 2. Phase and Neutral Buses: Provide mechanical lugs to accommodate the quantity, size, and material of the conductors shown on the Contract Drawings.
 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors. Bonded to box.
 4. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity the entire length of the panelboard. Provide for future extensions from both ends.
 5. Neutral Buses: 100 percent of the ampacity of the phase buses, except as indicated, and equipped with approved pressure connectors for outgoing circuit neutral cables.
- G. Future Devices: Equip with mounting brackets, supports, bus connections, and appurtenances for the overcurrent protective device ampere ratings indicated on the Drawings.
- H. Directory Frame: Clear plastic cardholder, mounted inside each panelboard door.
- I. Service Equipment Approval: Listed for use as service equipment for panelboards with main service disconnect.
- J. Special Features: Include the following features for panelboards as indicated:
1. Provide 200 percent rated neutral bus for all computer and non-linear loads.
 2. Subfeed: Over-current protective device or lug provision as indicated.
 3. Feed-Through Lugs: Provide mechanical lugs to accommodate the quantity, size, and material of the conductors shown on the Contract Drawings.
 4. Gutter Barrier: Arranged to isolate section of gutter as indicated.

2.3. OVERCURRENT PROTECTIVE DEVICES

- A. Overcurrent protective devices include, but are not limited to, the following:
1. Electronic trip circuit breakers.
 2. Thermal magnetic circuit breakers.
- B. Molded-Case Circuit Breaker Features and Accessories:
1. Characteristics: Frame size, trip rating, number of poles, and auxiliary devices as indicated and interrupting capacity rating to meet available fault current.
 2. Lugs: Mechanical style, suitable for quantity, size/gauge, and material of conductors indicated.
 3. Application Listing: Appropriate for application, including switching lighting loads (Type SWD) or heating, air-conditioning, and refrigerating equipment (Type HACR).
 4. Handle Padlock Attachment: Circuit breakers in panelboards shall be equipped

with fixed handle padlock attachment to allow padlocking the circuit breaker in the ON or OFF position at the following locations:

- a. Main circuit breakers in all panelboards.
 - b. Branch or sub-feed circuit breakers serving other panelboards.
 - c. Branch or sub-feed circuit breakers serving transformers.
 - d. Branch or sub-feed circuit breakers serving variable frequency drives.
 - e. Other locations as indicated on the Contract Drawings.
5. Handle Clamp Attachment: Circuit breakers in panelboards shall be equipped with removable handle clamp attachments to prevent accidental operation of the circuit breaker at the following locations:
- a. Branch circuit breakers serving emergency lighting and exit signs.
 - b. Branch circuit breakers serving fire alarm equipment.
 - c. Branch circuit breakers serving telecommunications equipment.
 - d. Branch circuit breakers serving refrigerators.
 - e. Branch circuit breakers serving electric heating cables.
 - f. Other locations as indicated on the Contract Drawings.
6. Shunt Trip: Trips the circuit breaker from a remote location by means of a trip coil energized from a separate circuit.
- a. 120 Vac coil set to trip at 55 percent of rated voltage for shunt trip coils interlocked with emergency pushbuttons, e.g. gas-fired mechanical equipment or lab panelboards.
7. Ground Fault Protection: Integral to circuit breaker with adjustable pickup and time delay settings, push-to-test feature, and ground-fault indicator.

2.4. POWER DISTRIBUTION PANELBOARDS

A. Interior

1. Continuous main current ratings as indicated on Contract Drawings not to exceed 1200 amperes maximum. Panelboard bus current ratings shall be determined by heat-rise tests in accordance with UL 67.
2. Provide UL listed short-circuit current ratings (SCCR) as indicated on the Contract Drawings, not to exceed the lowest interrupting capacity rating of any circuit breaker installed with a maximum of 200,000 RMS symmetrical amperes. Main lug and main circuit breaker panelboards shall be suitable for use as Service Equipment when application requirements comply with UL 67 and NEC Articles 230.VI and VII.
3. Minimum short-circuit current ratings for distribution panelboards shall be verified by short circuit analysis specified under Division 26 Section 260573, "Power System Studies", prior to ordering equipment.
4. The panelboard interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.
5. The bussing shall be fully rated with sequentially phased branch distribution. Bus

bar plating shall run the entire length of the bus bar. The entire interleaved assembly shall be contained between two (2) U-shaped steel channels, permanently secured to a galvanized steel mounting pan by fasteners.

6. Interior trim shall be of dead-front construction to shield user from all energized parts.
7. Main circuit breakers through 800 amperes shall be vertically mounted. Main circuit breaker and main lug interiors shall be field convertible for top or bottom incoming feed.
8. A solidly bonded equipment ground bar shall be provided.
9. Solid neutral shall be equipped with a full capacity bonding strap for service entrance applications. Gutter mounted neutral will not be acceptable.

B. Main Circuit Breakers – Electronic Trip Molded Case Type

1. Electronic trip, molded case, 80% rated circuit breaker with Micrologic® interchangeable ammeter trip unit with the following time/current response adjustments:
 - a. Long Time Pickup
 - b. Long Time Delay
 - c. Short Time Pickup
 - d. Short Time Delay
 - e. Instantaneous Settings
2. Circuit breakers where the highest continuous current trip setting can be adjusted to 1200A or higher, shall be equipped with arc energy reducing maintenance setting, in compliance with National Electrical Code Article 240.87.
3. All adjustments shall have discrete settings (fully adjustable) and shall be independent of all other adjustments.
4. Circuit breaker trip system shall be microprocessor-based true RMS sensing designed with sensing accuracy through the thirteenth (13th) harmonic.
5. Sensor ampere ratings shall be as indicated herein or on the Drawings.
6. Local visual trip indication for overload, short circuit [and ground fault] trip occurrences.
7. Long time pickup indication shall signal when loading approaches or exceeds the adjustable ampere rating of the circuit breaker.
8. Basis of Design: Square D Company, Micrologic® Power Trip Units.

C. Group Mounted Circuit Breakers Through 1200A

1. Circuit breaker(s) shall be group mounted plug-on with mechanical restraint on a common pan or rail assembly.
2. Circuit breaker(s) equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breaker(s) shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners. Circuit breaker(s) of different frame sizes shall be capable of being mounted across from each other.
3. All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.
4. Furnish thermal magnetic molded case circuit breakers for 250A frames and below.

D. Electronic Trip Molded Case Circuit Breakers

1. Electronic trip, molded case, 80% rated circuit breaker(s) with Micrologic® interchangeable ammeter trip unit and the following time/current response adjustments:
 - a. Long Time Pickup
 - b. Long Time Delay
 - c. Short Time Pickup
 - d. Short Time Delay
 - e. Instantaneous Settings
2. Circuit breakers where the highest continuous current trip setting can be adjusted to 1200A or higher, shall be equipped with arc energy reducing maintenance settings, in compliance with National Electrical Code Article 240.87.
3. All adjustments shall have discrete settings (fully adjustable) and shall be independent of all other adjustments.
4. Circuit breaker trip system shall be micro-processor based true RMS sensing designed with sensing accuracy through the thirteenth (13th) harmonic.
5. Sensor ampere trip ratings shall be as indicated on the Drawings.
6. Local visual trip indication for overload and short circuit trip occurrences.
7. Long time pickup indication to signal when loading approaches or exceeds the adjustable ampere rating of the circuit breaker shall be provided.

E. Thermal Magnetic Molded Case Circuit Breakers

1. Molded case circuit breakers shall have integral thermal and instantaneous magnetic trip in each pole.
2. Ampere ratings shall be as shown on the Contract Drawings.
3. Ampere interrupting capacity ratings shall be as shown on the Contact Drawings, but not less than 18,000 AIC RMS symmetrical amperes at rated voltage.

F. Enclosures

1. Type 1 Enclosures
 - a. Boxes shall be hot zinc dipped galvanized steel constructed in accordance with UL 50 requirements. Zinc-coated galvanized steel will not be acceptable.
 - b. Boxes shall have removable blank end walls and interior mounting studs. Interior support bracket shall be provided for ease of interior installation.
 - c. Trim front steel shall meet strength and rigidity requirements per UL 50 standards. Shall have an ANSI 49 medium gray enamel electrodeposited over cleaned phosphatized steel.
 - d. Trim front door shall be 4-piece surface and shall have rounded corners and edges free of burrs.
 - e. Locks shall be cylindrical tumbler type with larger enclosures requiring sliding vault locks with 3-point latching. All lock assemblies shall be keyed alike.

G. Basis of Design – Square D Company, I-LINE Distribution Panelboards.

2.5. LIGHTING AND APPLIANCE PANELBOARDS

A. Interior

1. Minimum short-circuit current ratings shall be as indicated on the Contract Drawings, but not less than 10,000 AIC RMS symmetrical amperes for 120/208V panelboards, and 18,000 AIC RMS symmetrical amperes for 277/480V panelboards.
2. Minimum short-circuit current ratings shall be verified by short circuit analysis specified under Division 26 Section 260573, “Power System Studies”, prior to ordering equipment.
3. Provide one (1) continuous bus bar per phase. Each bus bar shall have sequentially phased branch circuit connectors suitable for plug-on or bolt-on branch circuit breakers. The bussing shall be fully rated. Panelboard bus current ratings shall be determined by heat rise tests conducted in accordance with UL 67. Bus bar plating shall run the entire length of the bus bar.
4. Panelboards shall be suitable for use as Service Equipment when application requirements comply with UL 67 and NEC Article 230.
5. All current carrying parts shall be insulated from ground and phase to phase by high dielectric strength thermoplastic.
6. Interior trim shall be of dead front construction to shield user from energized parts. Dead front trim shall have pre-formed twist-outs covering unused mounting space.
7. Interiors shall be field convertible for top or bottom incoming feed.
8. Main circuit breakers shall be vertically mounted, unless otherwise indicated.
9. Sub-feed circuit breakers shall be vertically mounted.
10. Interior leveling provisions shall be provided for flush mounted applications.
11. Main lug interiors up to 400 amperes shall be field convertible to main breaker.

B. Main Circuit Breakers

1. Main circuit breakers shall have an over-center, trip free, toggle mechanism which will provide quick-make, quick-break contact action. Circuit breakers shall have a permanent trip unit with thermal and instantaneous magnetic trip elements in each pole. Each thermal element shall be true RMS sensing and be factory calibrated to operate in a 40 degrees C ambient environment. Thermal elements shall be ambient compensating above 40 degrees C.
2. Two and three pole circuit breakers shall have common tripping of all poles. Circuit breakers frame sizes above 100 amperes shall have a single magnetic trip adjustment located on the front of the circuit breaker that allows the user to simultaneously select the desired trip level of all poles. Circuit breakers shall have a push to trip button for maintenance and testing purposes.
3. Breaker handle and faceplate shall indicate rated ampacity. Standard construction circuit breakers shall be UL listed for reverse connection without restrictive line or load markings.

C. Branch Circuit Breakers

1. Molded case branch circuit breakers shall have bolt-on type bus connectors.
2. Circuit breakers shall have an over-center toggle mechanism which will provide quick-make, quick-break contact action. Circuit breakers shall have thermal and instantaneous magnetic trip elements in each pole. Two and three pole circuit

breakers shall have common tripping of all poles.

3. There shall be two forms of visible trip indication. The breaker handle shall reside in a position between ON and OFF. In addition, there shall be a red VISI TRIP indicator appearing in the clear window of the circuit breaker housing.
4. Circuit breakers serving transformers or other panelboards shall be equipped with factory-installed, fixed, handle padlock attachment to allow padlocking circuit breakers in the OFF only position.

D. Enclosures

1. Type 1 Enclosures

- a. Boxes shall be galvanized steel constructed in accordance with UL 50 requirements. Galvannealed steel will not be acceptable.
- b. Boxes shall have removable end-walls with knockouts located on one end. Boxes shall have welded interior mounting studs.
- c. Fronts shall meet strength and rigidity requirements per UL 50 standards. Front shall be finished with ANSI 49 gray baked enamel electrodeposited over cleaned phosphatized steel.
- d. Panelboards shall have hinged front cover with entire front trim hinged to box with standard door within hinged front cover.
- e. Front shall not be removable with the door locked.
- f. Doors on front shall have rounded corners and edges shall be free of burrs.
- g. A clear plastic directory card holder shall be mounted on the inside of the door.
- h. All lock assemblies shall be keyed alike, one (1) key shall be provided with each lock.

2. Type 3R/5/12 Enclosures

- a. Enclosures shall be constructed in accordance with UL 50 requirements. Enclosures shall be finished with ANSI 49 gray baked enamel electrodeposited over cleaned phosphatized steel.
- b. Doors shall be gasketed and be equipped with a locking vault handle.
- c. A clear plastic directory card holder shall be mounted on the inside of the door.
- d. All lock assemblies shall be keyed alike, one (1) key shall be provided with each lock.

E. Basis of Design – Square D Company, NQ/NF Series Panelboards.

2.6. SURGE PROTECTION DEVICES

- A. Description: Integrated Surge Protection Devices (SPDs) in panelboards.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Square D Company - "IMA" Series
 2. Eaton Corporation; Cutler-Hammer Products
 3. Siemens Energy & Automation, Inc.

4. General Electric (GE)
- 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. 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 242.
- 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 over-temperature 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. Distribution Panelboards: 240kA
 2. Branch Panelboards: 120kA
- 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:

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

L. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV):

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

- 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.
- O. The status of each SPD module shall be monitored on the front cover of the enclosure as well as on the module.
- P. 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.
- Q. 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.
- R. 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.
- S. Terminals shall be provided for necessary power and ground connections.
- T. 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.
- U. SPD shall have a warranty period of ten (10) years from date of invoice and shall include unlimited replacement of suppression modules within the warranty period. Warranty shall be the responsibility of the electrical distribution equipment manufacturer and shall be supported by their respective field service division.

2.7. IDENTIFICATION

- A. Nameplates: Engraved nameplates shall be provided for all panelboards. Nameplates shall give item designation and circuit number as well as frame size and appropriate trip rating. Furnish Master Nameplate giving panelboard designation, voltage ampere rating, short circuit rating, manufacturer's name, general order number and item number.
- B. Panelboards used as service-entrance equipment shall be labeled as the same.

- C. Refer to Division 26 Section 260553, "Identification for Electrical Systems", for additional information.

PART 3. EXECUTION

3.1. EXAMINATION

- A. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of panelboards.
1. Do not proceed with installation until unsatisfactory conditions have been corrected.
 2. Verify dimensions of panelboard and working space clearances.

3.2. 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. Panelboard dead fronts shall remain intact except where tabs are removed for circuit breakers. Install filler plates in unused pole spaces not filled by a circuit breaker that are accidentally opened. Do not remove all tabs in dead front and fill the same with filler plates.
- D. Provision for Future Circuits at Flush-Mounted Panelboards: Stub 1-inch (25 mm) empty conduits from panelboard into accessible ceiling space, in accordance with the following schedule. This requirement also applies to surface-mounted and flush-mounted panelboards installed in spaces with inaccessible ceilings.

Total Number of Single Pole Spares and Spaces	Number of 1-inch Empty Conduits
1 – 3	Two
4 – 6	Three
7 – 9	Four
10 – 12	Five
13 – 20	Ten
21 – 32	Fifteen

- E. Wiring in Panelboard Gutters: Arrange conductors into groups, and bundle and wrap with wire ties after completing load balancing.
- F. Two or three pole circuit breakers shall be common trip type. Single pole breakers with handle ties will not be permitted.
- G. Tandem circuit breakers will not be permitted.
- H. Provide ground buses in 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. Provide handle clamps for all branch circuit breakers serving telephone and communications equipment, refrigerators, exit signs, fire alarm system controls, etc. 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 electric heating cables shall be GFEP type for equipment protection (30mA).
- N. Branch circuit breakers serving receptacles and appliances located under kitchen ventilation hoods shall be equipped with shunt-trip mechanisms.
- O. 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 7 inches per NEC Article 404.8.
- P. Do not energize or connect service-entrance equipment and panelboards to their sources until surge protective devices are properly installed and connected.

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. IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section 260553, "Identification for Electrical Systems".

- B. Nameplates: Label each panelboard with engraved laminated-plastic or metal nameplates as detailed on the Contract Drawings. Refer to Division 26 Section 260553, “Identification for Electrical Systems”, for nameplate requirements.
- C. Circuit Directories:
 - 1. Panelboards shall have accurate typed circuit directories indicating exactly what each branch circuit serves.
 - 2. The Contractor shall provide up to date circuit directories in new and existing panelboards, indicating all deletions and additions, and to note the date of all changes on the directory.
 - 3. The circuit directories shall reflect the actual room numbers. Directories indicating the reference room numbers on the contract drawings or in the panelboard schedule shall not be acceptable.
 - 4. The circuit directories shall include the name, address, and contact information for the Electrical/Division 26 Contractor.
 - 5. If at any time after occupancy the circuit directories are found to be incorrect due to negligence by the installer, then the Contractor shall trace out circuits, and correct the directories at no additional cost to the Owner.

3.6. FIELD QUALITY CONTROL

- A. 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. Clean devices using Manufacturer’s approved methods and materials.
 - 3. Verify that panelboard nameplates are installed and accurate.
 - 4. Verify that panelboard phase identification nameplates are installed.
 - 5. Verify that panelboard arc flash hazard labels are installed.
 - 6. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer’s instruction manual.
 - 7. Check panelboard mounting, area clearances, and alignment and fit of components.
 - 8. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer’s instructions for proper torque values.
 - 9. Perform visual and mechanical inspection and related work for over-current protective devices.
 - 10. Verify that all neutral conductors are bonded to the system ground at the service-entrance prior to installation of the surge protective device.
 - 11. Verify that neutral-ground bonds do not exist at locations that are not service entrances or separately derived power sources.
- B. Panelboard Electrical Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing. 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.
 - 2. 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.
3. 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.
 4. 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.
 5. Make continuity tests of each circuit. Refer to Division 26 Section 260519, "Low-Voltage Electrical Power Conductors and Cables" for testing specific to feeder conductors.
 6. Perform ground resistance test on system and equipment ground connections
 7. Test main and sub-feed overcurrent protective devices.
 8. Test ground fault devices in accordance with NETA ATS 7.14.
 9. NETA Testing:
 - a. 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, for all devices rated 100-amperes and larger.
 - b. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - c. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
 10. Infrared Scanning: Perform an infrared scan of all electrical connections in each panelboard, as follows:
 - a. Remove equipment covers so terminations are accessible to scanner.
 - b. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values.
 - c. Provide calibration record for device.
 - d. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - e. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
 11. Test Labeling: On satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.
 12. Submit all test reports to the Architect for review and approval.
 13. Provide copy of all test reports in the O&M manual.

3.7. ADJUSTING

- A. Set field-adjustable circuit-breaker trip ranges as indicated in coordination study provided under Division 26 Section 260573, "Power System Studies".

3.8. CLEANING

- A. Upon 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.

3.9. PROTECTION

- A. Provide final protection and maintain conditions in a manner that shall ensure that the panelboard(s) shall be without damage at time of Substantial Completion.

3.10. DEMONSTRATION AND TRAINING

- A. Provide a minimum of four (4) hours of training and demonstration of panelboard operations, settings, adjustment, and maintenance.
- B. Topics to be covered include, but are not limited to, the following:
 - 1. Operation of electronic trip circuit breakers.
 - 2. Operation of arc energy reduction maintenance switches.

END OF SECTION

DIVISION 26 SECTION 26 24 17
FUSIBLE PANELBOARDS
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SECTION 26 24 17 – FUSIBLE 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.
- 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, “Identification for Electrical Systems”, for identification materials for labeling fusible panelboards, including, but not limited to equipment nameplates.
 - 3. Division 26 Section 260573, “Power System Studies”, for engineering analysis involving panelboards specified herein, including but not limited to short-circuit analysis.
 - 4. Division 26 Section 262416, “Panelboards”, for distribution and branch circuit panelboards rated 600V and less.
 - 5. Division 26 Section 264218, “Load Centers”, for requirements for load centers to be furnished with engine generators.
 - 6. Division 26 Section 264113, “Lightning Protection for Structures”, for requirements for lightning protection systems specific to surge protective devices serving panelboards as specified herein.

1.2. SUMMARY

- A. This Section includes fusible distribution and branch circuit panelboards and associated auxiliary equipment rated 600 V and less, intended for serving emergency and/or legally required power supply systems.
- B. Provide design and engineering, labor, material, equipment, related services and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for panelboards as required for the complete performance of the work, and as shown on the Drawings and as specified herein.
- C. Fusible panelboards shall be fully rated for the AIC identified on the panelboard schedules on the Contract Drawings. Fusible panelboards shall be tested, listed, and labeled for the available short circuit current.
- D. Minimum short-circuit current ratings for fusible panelboards shall be verified by short circuit analysis specified under Division 26 Section 260573, “Power System Studies”, prior to ordering equipment.

1.3. REFERENCES

- A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the

Contract Documents, unless otherwise specified.

- B. American Society of Testing Materials (ASTM):
 - 1. ASTM E 329, “Standard Specification for Agencies Engaged in the Testing and/or inspection of Materials Used in Construction.”
- C. Federal Specifications (FS):
 - 1. FS W-C-375, “Circuit Breakers, Molded Case, Branch Circuit and Service.”
- D. International Electrical Testing Association (NETA):
 - 1. NETA ATS, “Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.”
- E. International Organization for Standardization (ISO):
 - 1. ISO 9001, “Quality Management Systems – Requirements.”
- F. National Electrical Contractors Association (NECA):
 - 1. NECA 407, “Standard for Installing and Maintaining Panelboards.”
- G. National Electrical Manufacturers Association (NEMA):
 - 1. NEMA PB 1, “Panelboards.”
 - 2. NEMA PB 1.1, “General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.”
- H. National Fire Protection Association (NFPA):
 - 1. NFPA 70, “National Electrical Code.”
 - 2. NFPA 70B, “Electrical Equipment Maintenance.”
 - 3. NFPA 70E, “Standard for Electrical Safety in the Workplace.”
- I. Underwriters Laboratories, Inc. (UL):
 - 1. UL 50, “Standard for Enclosures for Electrical Equipment.”
 - 2. UL 67, “Standard for Panelboards.”
 - 3. UL 489, “Standard for Molded-Case Circuit Breakers and Circuit Breaker Enclosures.”

1.4. SUBMITTALS

- A. Product Data: Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications.
 - 1. Submit product data for each type of fusible panelboard, overcurrent protective device, accessory, and component indicated.
 - 2. Include dimensions and manufacturer’s technical data on features, performance,

electrical characteristics, ratings, and finishes of individual protective devices and auxiliary components.

- B. Shop Drawings: Include the following for each panelboard:
 - 1. Dimensioned Plans: Show dimensioned enclosure plans and elevations, including required clearances and service space.
 - 2. Component and Device Lists: Show tabulations of installed devices, features and voltage rating.
 - 3. Single-Line Diagram: Show main- and branch-bus current ratings and short-time and short-circuit ratings of panelboards.
 - 4. Wiring Diagrams: Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer-installed and field-installed wiring, and between components provided by the manufacturer and those provided by others.
 - 5. Nameplate Legends: Submit sample equipment nameplates for panelboards.
- C. Quality Control Submittals: Submit field quality control test reports certified by testing agency.
- D. Contract Closeout Submittals:
 - 1. Operation and Maintenance Data: Submit operation and maintenance data for panelboards to include in operation and maintenance manuals specified in Division 01.
 - 2. Warranty Data: Submit manufacturer's standard warranty documents.
 - 3. Panelboard Circuit Directories: For installation in panelboards. Submit final versions in operation and maintenance manuals.
 - 4. Project Record Data: Record actual locations of panelboards, indicating actual branch circuit arrangement.

1.5. QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of panelboards of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 20 years. The manufacturer shall be ISO 9001 certified and shall be designed to internationally accepted standards.
- B. Installer Qualifications: Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing panelboards similar in type and scope to that required for this Project.
- C. Testing Agency Qualifications: In addition to the 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 National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3 of this Section.

- D. 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.

1.6. DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and lot number, if any.
- B. Store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.
- C. Store so condensation will not occur on or in panelboards. Provide temporary heaters as required to avoid condensation.
- D. Handle fusible panelboards according to NEMA PB 1.1. Use only factory-installed lifting provisions.

1.7. PROJECT CONDITIONS

- A. Environmental Requirements: Do not install panelboards until space is enclosed and weatherproof, wet work space is completely and nominally dry, overhead work is complete, and ambient temperature and humidity conditions are and will be continuously maintained at values near those indicated for final occupancy.
- B. Verify Dimensions: Verify NEC and all Code clearance requirements by field measurements. Locate fusible panelboards to meet installation tolerances.
- C. Determine suitable path for moving fusible panelboard(s) into place considering Project conditions.
- D. Revise locations and elevations from those indicated as required to suit Project conditions.

1.8. 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. 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.

1.9. EXTRA MATERIALS

- A. Keys: Provide two (2) spares of each type of fusible panelboard cabinet lock.
- B. Touchup Paint: Provide one (1) standard size canisters of manufacturer's touch-up paint for every ten (10) fusible panelboards, finish to match standard enclosure finish as specified herein. Furnish at least one (1) canister of touch-up paint.
- C. Fuses for Fusible Panelboards: Provide 20% or minimum of three fuses of each rating and type of fuse installed, in a spare fuse cabinet mounted in the same room(s) as the fusible panelboard(s).

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, supply equipment from one of the following manufacturers; no other manufacturers are acceptable:
 - 1. Square D Company. (Basis of Design for fusible distribution panelboards)
 - 2. Eaton Corp.; Cutler-Hammer Products.
 - 3. General Electric (GE)
 - 4. Mersen (Basis of Design for fusible branch panelboards)
 - 5. Siemens Energy & Automation Inc.

2.2. FABRICATION AND FEATURES

- A. Enclosures: Provide steel enclosures, in compliance with NEMA PB1, suitable for flush- or surface-mounting as indicated on the Drawings. Type as indicated on the Drawings, unless otherwise indicated to meet environmental conditions at installed location as indicated below:
 - 1. Dry, Interior Locations: NEMA 1
- B. NEMA 1 enclosures shall be surface or flush mount as indicated in associated schedules or drawings. NEMA 3R enclosures shall be surface mount only.
- C. Enclosure Finish for Indoor Units: A minimum of one (1) coat of factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- D. Front: Secured to box with concealed trim clamps, unless otherwise indicated. Front for surface-mounted panelboards shall be same dimensions as box. Fronts for flush-mounted panelboards shall overlap box, unless otherwise indicated.
- E. Panelboard trim shall be dead-front construction covering all energized parts.
- F. Buses and Connections: Three phase, four wire, unless otherwise indicated.
 - 1. Bus Composition: Silver-plated or tin-plated copper, hard-drawn, minimum of 98 percent conductivity. Plating shall be applied continuously to bus work. The panelboard bussing shall be of sufficient cross-sectional area to meet UL 67

- temperature rise requirements. The phase and neutral through-bus shall have an ampacity as shown on the Drawings. Coordinate bus short circuit rating with available fault current. Size in accordance with NEMA PB 1.
 2. Phase and Neutral Buses: Provide mechanical lugs to accommodate the quantity, size, and material of the conductors shown on the Contract Drawings.
 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors. Bonded to box.
 4. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity the entire length of the panelboard. Provide for future extensions from both ends.
 5. Neutral Buses: 100 percent of the ampacity of the phase buses, except as indicated, and equipped with approved pressure connectors for outgoing circuit neutral cables.
- G. Future Devices: Equip with mounting brackets, supports, bus connections, and appurtenances for the overcurrent protective device ampere ratings indicated on the Drawings.
- H. Directory Frame: Clear plastic cardholder, mounted inside each panelboard door.
- I. Service Equipment Approval: Listed for use as service equipment for panelboards with main service disconnect.
- J. Special Features: Include the following features for panelboards as indicated:
1. Provide 200 percent rated neutral bus for all computer and non-linear loads.
 2. Subfeed: Over-current protective device or lug provision as indicated.
 3. Feed-Through Lugs: Provide mechanical lugs to accommodate the quantity, size, and material of the conductors shown on the Contract Drawings.
 4. Gutter Barrier: Arranged to isolate section of gutter as indicated.

2.3. OVERCURRENT PROTECTIVE DEVICES

- A. Overcurrent protective devices include, but are not limited to, the following:
1. Fusible switches (for fusible distribution panelboards and mains in fusible branch circuit panelboards).
 2. Fuses.
 3. Thermal magnetic circuit breakers (for fusible branch circuit panelboards).
- B. Molded-Case Circuit Breaker Features and Accessories:
1. Characteristics: Frame size, trip rating, number of poles, and auxiliary devices as indicated and interrupting capacity rating to meet available fault current.
 2. Lugs: Mechanical style, suitable for quantity, size/gauge, and material of conductors indicated.
 3. Application Listing: Appropriate for application, including switching lighting loads (Type SWD) or heating, air-conditioning, and refrigerating equipment (Type HACR).

2.4. FUSIBLE DISTRIBUTION PANELBOARDS

- A. Description: Fusible distribution panelboards rated up to 1200-amperes, for selective coordination in emergency and legally required standby power supply systems.
- B. Interior
 - 1. Continuous main current ratings as indicated on Contract Drawings not to exceed 1200 amperes maximum. Panelboard bus current ratings shall be determined by heat-rise tests in accordance with UL 67.
 - 2. Provide UL listed short-circuit current ratings (SCCR) as indicated on the Contract Drawings, not to exceed the lowest interrupting capacity rating of any circuit breaker installed with a maximum of 200,000 RMS symmetrical amperes. Main lug and main circuit breaker panelboards shall be suitable for use as Service Equipment when application requirements comply with UL 67 and NEC Articles 230.VI and VII.
 - 3. Minimum short-circuit current ratings for fusible distribution panelboards shall be verified by short circuit analysis specified under Division 26 Section 260573, “Power System Studies”, prior to ordering equipment.
 - 4. The panelboard interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.
 - 5. The bussing shall be fully rated with sequentially phased branch distribution. Bus bar plating shall run the entire length of the bus bar. The entire interleaved assembly shall be contained between two (2) U-shaped steel channels, permanently secured to a galvanized steel mounting pan by fasteners.
 - 6. Interior trim shall be of dead-front construction to shield user from all energized parts.
 - 7. A solidly bonded equipment ground bar shall be provided.
 - 8. Solid neutral shall be equipped with a full capacity bonding strap for service entrance applications. Gutter mounted neutral will not be acceptable.
- C. Main Fused Power Circuit Device(s)
 - 1. Fixed, individually-mounted bolted pressure switch(es) through 1200 amperes; rating as indicated on the Contract Drawings.
 - 2. Each device shall have power terminals to accommodate either cable or bolted bus connections.
 - 3. The overcurrent protective device(s) shall be of the fusible bolted pressure contact type.
 - 4. Switches, with Class “L” fuses installed, shall be rated for use on systems capable of delivering not more than 200,000 RMS symmetrical amperes at 600 VAC maximum.
 - 5. Switches shall have an interrupting rating of 12 times continuous ampere rating at 240, 480, and 600 VAC.
 - 6. Switches shall be 100% rated devices.
 - 7. All switches shall have switch blades which are fully visible in the open (OFF) position when the fuse access door is open.
 - 8. Bolted pressure contacts shall be made by providing an additional pressure or clamping action at both ends of the switch blade when the blades are fully closed.

- Switches having butt-type contacts are not acceptable.
9. Manual-operated switches shall have quick-make, quick-break front operating mechanisms.
 10. Switches shall have dual fuse door interlock designed to prevent the fuse access door from being opened when the switch is in the ON position and prevents the switch from being turned ON while the fuse access door is open. A means of bypassing the interlock by authorized personnel shall be provided to allow the switch to be inspected in the closed position. An external mechanical flag shall be provided to identify whether the switch is open or closed.
 11. Provisions for locking the switch in the OFF position shall be provided.

D. Branch Fusible Devices

1. Group-mounted, fusible switches rated 30 amperes through 1200 amperes.
2. Fusible switches shall be group-mounted, plug-on with mechanical restraint. No additional hardware shall be required to mount the fusible switch into the switchboard.
3. Modular construction shall permit 30 ampere through 1200 ampere devices to be field-installed by the Contractor.
4. Line side fusible switch connections shall be jaw type construction.
5. The operating mechanism shall be spring driven, with quick-make, quick-break action. Operating handles shall be flange mounted as an integral part in the operating mechanism. Switch contact shall be knife-blade and jaw construction. Switch shall include visible blades as a positive blade status indicator.
6. Switches shall be secured to the bus with spring reinforced jaw assemblies. In the event of a short circuit condition, the increased magnetic flux shall cause the jaws to grip the bus more firmly.
7. Fusible switch units shall be equipped with all required mounting brackets and guides.
8. Switches shall have dual fuse door interlock designed to prevent the fuse access door from being opened when the switch is in the ON position and prevents the switch from being turned ON while the fuse access door is open. A means of bypassing the interlock by authorized personnel shall be provided to allow the switch to be inspected in the closed position.
9. Provisions for locking the switch in the OFF position shall be provided.
10. There shall be two forms of visible ON/OFF indication:
 - a. A dual-color operating handle
 - b. Large steel ON/OFF nameplate with the O/I international markings. The universal nameplate shall be readable regardless of the switch orientation. Each nameplate shall furnish an easily removable circuit directory card.
11. Fusible switches shall be UL listed when equipped with field-installable accessories:
 - a. Mechanical lugs.
 - b. Electrical interlocks.
12. Fusible switches rated 30 amperes through 100 amperes shall have fuse pullers. The fuse puller design shall be of the type that the line side of the fuse is disconnected from the switch before the load side of the fuse is removed.

13. Fuse clips shall be designed to accommodate Class “J” or Class “R” fuses for switches rated 30 amperes to 600 amperes. Refer to Division 26 Section “Fuses” for fuse selection criteria.
14. Provide Class “L” fuses for all devices rated greater than 600 amperes.
15. Basis of Design: Square D Company, QMJ/QMB Series Fusible Switches

E. Enclosures

1. Type 1 Enclosures

- a. Boxes shall be hot zinc dipped galvanized steel constructed in accordance with UL 50 requirements. Zinc-coated galvanized steel will not be acceptable.
- b. Boxes shall have removable blank end walls and interior mounting studs. Interior support bracket shall be provided for ease of interior installation.
- c. Trim front steel shall meet strength and rigidity requirements per UL 50 standards. Shall have an ANSI 49 medium gray enamel electrodeposited over cleaned phosphatized steel.
- d. Trim front door shall be 4-piece surface and shall have rounded corners and edges free of burrs.
- e. Locks shall be cylindrical tumbler type with larger enclosures requiring sliding vault locks with 3-point latching. All lock assemblies shall be keyed alike.

F. Basis of Design – Square D Company, QMB Fusible Switch Distribution Panelboards

2.5. FUSIBLE BRANCH CIRCUIT PANELBOARDS

A. Description: Combination circuit breaker and fusible branch circuit panelboards for selective coordination in emergency power supply systems.

B. Panelboard Ratings:

1. Panelboards shall be labeled with a short-circuit current rating (SCCR) equal to or greater than that indicated on the associated schedules or drawings.
2. Non-service and service entrance rated panelboards shall be UL listed.
3. Panelboards shall be rated 600Vac and have a current rating as indicated on the associated schedules or drawings.
4. Panelboard overcurrent protective device interrupting ratings shall be UL listed and rated for the maximum available fault current.
5. Current ratings, configuration of poles and number of circuits shall be indicated on associated schedules or drawings.

C. Construction:

1. Panelboard branch circuits shall incorporate overcurrent protection using fuse types that are manufactured by at least three independent companies to assure replacement availability.
2. Interiors shall be factory assembled.
3. Bus bars shall be tin-plated copper with sufficient cross-sectional area to meet UL 67 temperature rise requirements.

4. 200 ampere rated neutral shall be standard, 400 ampere rated neutral shall be provided where indicated in the associated schedules or drawings.
5. Bonded neutral shall be provided where specified in associated drawings.
6. Isolated or non-isolated equipment ground bar shall be provided as indicated in the associated schedules or drawings.
7. Where a service-entrance rated panelboard is indicated in associated schedules or drawings, a bonded neutral and non-isolated equipment ground bar shall be provided by the manufacturer.
8. Main lug conductor terminations:
 - a. MLO terminations shall be rated for 60/75°C, Cu-Al
 - b. Main disconnect terminations shall be rated for 75°C, Cu Only

D. Main Disconnect:

1. Where specified in the drawings, permanently installed lockout means shall be provided on the main disconnect for lock out tagout (LOTO) procedures.
2. Main disconnect shall be quick-make, quick-break type.

E. Branch Circuit Overcurrent Protection:

1. Both circuit breaker and fuse shall have visible circuit ON/OFF indication.
2. Fuse holder shall provide open fuse indication via permanently installed neon indicating light where indicated on the plans and specifications.
3. Overcurrent protective devices shall be UL Listed, with voltage and short-circuit current ratings meeting the available voltage and short current shown on the drawings. The combination circuit breaker and fuse shall have amperage ratings and number of poles as indicated on the panelboard schedule.
4. Circuit breakers and fuses shall be finger-safe components with trim installed.
5. Fuse holder shall be designed so as not to allow fuse removal while fuse terminals are energized.
6. No special tools shall be required for fuse removal.
7. Breakers and fuses shall be clearly marked with device amperage.
8. Circuit breakers and fuses shall be clearly marked with device amperage.
9. Branch overcurrent protective devices shall minimize the types and rating of fuses to only 30A, 60A and 100A for simple maintenance.
10. Branch circuit load terminations shall be UL listed for one and two wires per terminal.
11. Multipole branch circuit overcurrent protection devices shall trip on an overcurrent of any pole to prevent single-phasing of the load.
12. Branch circuit overcurrent protection devices shall be “Bolt In.”
13. Branch circuit overcurrent protection devices shall be resettable without replacing fuses for overcurrents for at least twice their rating.
14. Short circuits shall be cleared within ½ cycle to prevent sensitive equipment disruptions.

F. Main and Branch Overcurrent Protection:

1. All fuse protective devices shall have a minimum interrupting rating of 200kA.
2. Branch circuit overcurrent protection shall be UL Listed for the voltages specified on the drawings.

3. Main overcurrent protective devices shall be UL Listed for the voltages specified on the drawings.

G. Enclosures:

1. Boxes with 60A and less branch circuits shall be a nominal 20 inches wide and 6 inches deep with wire bending space per the National Electrical Code®.
2. Panelboard trim shall be supplied with lockable door covering all circuit breaker and disconnect handles.
3. Type 1 Enclosures
 - a. Boxes shall be galvanized steel constructed in accordance with UL 50 requirements. Galvannealed steel will not be acceptable.
 - b. Boxes shall have removable end-walls with knockouts located on one end. Boxes shall have welded interior mounting studs.
 - c. Fronts shall meet strength and rigidity requirements per UL 50 standards. Front shall be finished with ANSI 49 gray baked enamel electrodeposited over cleaned phosphatized steel.
 - d. Panelboards shall have hinged front cover with entire front trim hinged to box with standard door within hinged front cover.
 - e. Front shall not be removable with the door locked.
 - f. Doors on front shall have rounded corners and edges shall be free of burrs.
 - g. A clear plastic directory card holder shall be mounted on the inside of the door.
 - h. All lock assemblies shall be keyed alike, one (1) key shall be provided with each lock.

H. Basis of Design: Mersen Fused Coordination Panelboard type MFPCP or approved equal.

2.6. SURGE PROTECTION DEVICES

- A. All fusible panelboards on emergency power supply systems (EPSS) shall be protected surge protection devices.
- B. Description: Integrated Surge Protection Devices (SPDs) in panelboards.
- C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Square D Company
 2. Eaton Corporation; Cutler-Hammer Products
 3. Mersen
- D. 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.
- E. Standards - Most recent editions of:
 1. Underwriters Laboratories:
 - a. 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"
- F. 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.
- G. 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 242.
- H. 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 over-temperature controls.
- I. 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."
- J. Minimum surge current capability (single pulse rated) per phase shall be as follows:
1. Distribution Panelboards: 240kA
 2. Branch Panelboards: 120kA
- K. 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.
- L. UL 1449 Listed Voltage Protection Ratings (VPRs) shall not exceed the following:

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

- M. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV):

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

- N. SPD shall be constructed of one self-contained suppression module per phase.
- O. 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.
- P. The status of each SPD module shall be monitored on the front cover of the enclosure as well as on the module.
- Q. 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.
- R. 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.
- S. 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.
- T. Terminals shall be provided for necessary power and ground connections.
- U. 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.
- V. SPD shall have a warranty period of ten (10) years from date of invoice and shall include unlimited replacement of suppression modules within the warranty period. Warranty shall be the responsibility of the electrical distribution equipment manufacturer and shall be supported by their respective field service division.

2.7. IDENTIFICATION

- A. Nameplates: Engraved nameplates shall be provided for all panelboards. Nameplates shall give item designation and circuit number as well as frame size and appropriate trip rating. Furnish Master Nameplate giving panelboard designation, voltage ampere rating, short circuit rating, manufacturer's name, general order number and item number.
- B. Panelboards used as service-entrance equipment shall be labeled as the same.
- C. Refer to Division 26 Section 260553, "Identification for Electrical Systems", for additional information.

PART 3. EXECUTION

3.1. EXAMINATION

- A. Examine elements and surfaces to receive fusible panelboards for compliance with installation tolerances and other conditions affecting performance of fusible panelboards.

1. Do not proceed with installation until unsatisfactory conditions have been corrected.
2. Verify dimensions of fusible panelboard and working space clearances.

3.2. INSTALLATION

- A. Install fusible panelboards and accessory items according to NEMA PB 1.1.
- B. Mounting: Plumb and rigid without distortion of box.
- C. Panelboard dead fronts shall remain intact except where tabs are removed for circuit breakers. Install filler plates in unused pole spaces not filled by a circuit breaker that are accidentally opened. Do not remove all tabs in dead front and fill the same with filler plates.
- 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. Provide ground buses in panelboards as indicated on the Drawings. Ground bus shall be similar in all respects to neutral bus.
- H. 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 7 inches per NEC Article 404.8.
- I. Do not energize or connect service-entrance equipment and panelboards to their sources until surge protective devices are properly installed and connected.

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. IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section 260553, “Identification for Electrical Systems”.
- B. Nameplates: Label each panelboard with engraved laminated-plastic or metal nameplates as detailed on the Contract Drawings. Refer to Division 26 Section 260553, “Identification for Electrical Systems”, for nameplate requirements.
- C. Circuit Directories:
 - 1. Panelboards shall have accurate typed circuit directories indicating exactly what each branch circuit serves.
 - 2. The Contractor shall provide up to date circuit directories in new and existing panelboards, indicating all deletions and additions, and to note the date of all changes on the directory.
 - 3. The circuit directories shall reflect the actual room numbers. Directories indicating the reference room numbers on the contract drawings or in the panelboard schedule shall not be acceptable.
 - 4. The circuit directories shall include the name, address, and contact information for the Electrical/Division 26 Contractor.
 - 5. If at any time after occupancy the circuit directories are found to be incorrect due to negligence by the installer, then the Contractor shall trace out circuits, and correct the directories at no additional cost to the Owner.

3.6. FIELD QUALITY CONTROL

- A. 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. Clean devices using Manufacturer’s approved methods and materials.
 - 3. Verify that panelboard nameplates are installed and accurate.
 - 4. Verify that panelboard phase identification nameplates are installed.
 - 5. Verify that panelboard arc flash hazard labels are installed.
 - 6. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer’s instruction manual.
 - 7. Check panelboard mounting, area clearances, and alignment and fit of components.
 - 8. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer’s instructions for proper torque values.
 - 9. Perform visual and mechanical inspection and related work for over-current protective devices.
 - 10. Verify that all neutral conductors are bonded to the system ground at the service-entrance prior to installation of the surge protective device.
 - 11. Verify that neutral-ground bonds do not exist at locations that are not service entrances or separately derived power sources.
- B. Panelboard Electrical Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing. 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.
2. 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.
 3. 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.
 4. 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.
 5. Make continuity tests of each circuit. Refer to Division 26 Section 260519, "Low-Voltage Electrical Power Conductors and Cables" for testing specific to feeder conductors.
 6. Perform ground resistance test on system and equipment ground connections
 7. Test main and sub-feed overcurrent protective devices.
 8. NETA Testing:
 - a. 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, for all devices rated 100-amperes and larger.
 - b. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - c. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
 9. Infrared Scanning: Perform an infrared scan of all electrical connections in each panelboard, as follows:
 - a. Remove equipment covers so terminations are accessible to scanner.
 - b. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values.
 - c. Provide calibration record for device.
 - d. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - e. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
 10. Test Labeling: On satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.
 11. Submit all test reports to the Architect for review and approval.
 12. Provide copy of all test reports in the O&M manual.

3.7. ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges as indicated in coordination study provided under Division 26 Section 260573, "Power System Studies".

3.8. CLEANING

- A. Upon 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.

3.9. PROTECTION

- A. Provide final protection and maintain conditions in a manner that shall ensure that the panelboard(s) shall be without damage at time of Substantial Completion.

3.10. DEMONSTRATION AND TRAINING

- A. Provide a minimum of four (4) hours of training and demonstration of panelboard operations, settings, adjustment, and maintenance.
- B. Topics to be covered include, but are not limited to, the following:
 - 1. Operation of fusible panelboards, including fuse replacement.

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DIVISION 26 SECTION 26 24 18
LOAD CENTERS
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SECTION 26 24 18 – LOAD CENTERS

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.
- 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, “Identification for Electrical Systems”, for identification materials for labeling load centers, including, but not limited to equipment nameplates.
 - 3. Division 26 Section 260573, “Power System Studies”, for engineering analysis involving load centers specified herein, including but not limited to short-circuit analysis.
 - 4. Division 26 Section 262416, “Panelboards”, for distribution and branch circuit panelboards rated 600V and less.
 - 5. Division 26 Section 262417, “Fusible Panelboards”, for fusible distribution and branch circuit panelboards rated 600V and less serving emergency and/or legally required power supply systems.

1.2. SUMMARY

- A. This Section includes load centers and associated auxiliary equipment rated 240 V and less.
- B. Provide design and engineering, labor, material, equipment, related services and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for load centers as required for the complete performance of the work, and as shown on the Drawings and as specified herein.
- C. Load centers shall be fully rated for the AIC identified on the load center schedules on the Contract Drawings. Load centers shall be tested, listed, and labeled for the available short circuit current.
- D. Minimum short-circuit current ratings for load centers shall be verified by short circuit analysis specified under Division 26 Section 260573, “Power System Studies”, prior to ordering equipment.

1.3. SUBMITTALS

- A. Product Data: For each type of load center, accessory item, and component specified.
- B. Shop Drawings: For each load center. 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 load center.
 4. Features, 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. Load Center Schedules: For installation in load centers.
- E. Contract Closeout Submittals:
1. Operation and Maintenance Data: Submit operation and maintenance data for load centers to include in operation and maintenance manuals specified in Division 01.
 2. Warranty Data: Submit manufacturer's standard warranty documents.
 3. Load Center Circuit Directories: For installation in load centers. Submit final versions in operation and maintenance manuals.
 4. Project Record Data: Record actual locations of load centers, indicating actual branch circuit arrangement.

1.4. QUALITY ASSURANCE

- A. 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.
- B. Comply with NFPA 70, National Electrical Code.
- C. Comply with NEMA AB1, Molded Case Circuit Breakers.
- D. Comply with NEMA PB1, Panelboards.
- E. Comply with NEMA PB1.1, Instructions for Safe Installation, Operation & Maintenance of Panelboards Rated 600 Volts or Less.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, supply equipment from one of the following manufacturers; no other manufacturers are acceptable:
 - 1. Square D Company. (Basis of Design).
 - 2. Eaton Corp.; Cutler-Hammer Products.
 - 3. Siemens Energy & Automation Inc.

2.2. FABRICATION AND FEATURES

- A. Enclosures: Provide steel enclosures, in compliance with NEMA PB1, suitable for flush- or surface-mounting as indicated on the Drawings. Type as indicated on the Drawings, unless otherwise indicated to meet environmental conditions at installed location as indicated below:
 - 1. Dry, Interior Locations: NEMA 1
 - 2. Damp, Wet Interior Locations: NEMA 3R
 - 3. Damp, Wet Exterior Locations: NEMA 3R
- B. NEMA 1 enclosures shall be surface or flush mount as indicated in associated schedules or drawings. NEMA 3R enclosures shall be surface mount only.
- C. Enclosure Finish for Indoor Units: A minimum of one (1) coat of factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- D. Front: Secured to box with concealed trim clamps, unless otherwise indicated. Front for surface-mounted load centers shall be same dimensions as box. Fronts for flush-mounted load centers shall overlap box, unless otherwise indicated.
- E. Load center trim shall be dead-front construction covering all energized parts.
- F. Buses and Connections: Single phase/three wire, or three phase/ four wire, as indicated on the Contract Drawings:
 - 1. Bus Composition: Silver-plated or tin-plated copper, hard-drawn, minimum of 98 percent conductivity. Plating shall be applied continuously to bus work. The load center bussing shall be of sufficient cross-sectional area to meet UL 67 temperature rise requirements. The phase and neutral through-bus shall have an ampacity as shown on the Drawings. Coordinate bus short circuit rating with available fault current. Size in accordance with NEMA PB 1.
 - 2. Phase and Neutral Buses: Provide mechanical lugs to accommodate the quantity, size, and material of the conductors shown on the Contract Drawings.
 - 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors. Bonded to box.
 - 4. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity the entire length of the load center. Provide for future extensions from

both ends.

5. Neutral Buses: 100 percent of the ampacity of the phase buses, except as indicated, and equipped with approved pressure connectors for outgoing circuit neutral cables.
- G. Future Devices: Equip with mounting brackets, supports, bus connections, and appurtenances for the overcurrent protective device ampere ratings indicated on the Drawings.
- H. Directory Frame: Clear plastic cardholder, mounted inside each load center door.
- I. Service Equipment Approval: Listed for use as service equipment for load centers with main service disconnect.
- J. Basis of Design: Square D Company QO Load Centers.

2.3. OVERCURRENT PROTECTIVE DEVICES

- A. Overcurrent protective devices include, but are not limited to, the following:
 1. Thermal magnetic circuit breakers.
- B. Molded-Case Circuit Breaker Features and Accessories:
 1. Characteristics: Frame size, trip rating, number of poles, and auxiliary devices as indicated and interrupting capacity rating to meet available fault current.
 2. Lugs: Mechanical style, suitable for quantity, size/gauge, and material of conductors indicated.
 3. Application Listing: Appropriate for application, including switching lighting loads (Type SWD) or heating, air-conditioning, and refrigerating equipment (Type HACR).
 4. Handle Padlock Attachment: Circuit breakers in load center shall be equipped with fixed handle padlock attachment to allow padlocking the circuit breaker in the OFF only position at the following locations:
 - a. Main circuit breakers in all load centers.
 - b. Other locations as indicated on the Contract Drawings.
 5. Handle Clamp Attachment: Circuit breakers in load centers shall be equipped with removable handle clamp attachments to prevent accidental operation of the circuit breaker at the following locations:
 - a. Branch circuit breakers serving emergency circuits.
 - b. Other locations as indicated on the Contract Drawings.

2.4. LOAD CENTERS

- A. Interior

1. Minimum short-circuit current ratings shall be as indicated on the Contract Drawings, but not less than 10,000 AIC RMS symmetrical amperes for 120/208V and 120/240V load centers.
2. Minimum short-circuit current ratings shall be verified by short circuit analysis specified under Division 26 Section 260573, “Power System Studies”, prior to ordering equipment.
3. Provide one (1) continuous bus bar per phase. Each bus bar shall have sequentially phased branch circuit connectors suitable for plug-on branch circuit breakers. The bussing shall be fully rated. Load center bus current ratings shall be determined by heat rise tests conducted in accordance with UL 67. Bus bar plating shall run the entire length of the bus bar.
4. Load centers shall be suitable for use as Service Equipment when application requirements comply with UL 67 and NEC Article 230.
5. All current carrying parts shall be insulated from ground and phase to phase by high dielectric strength thermoplastic.
6. Interior trim shall be of dead front construction to shield user from energized parts. Dead front trim shall have pre-formed twist-outs covering unused mounting space.
7. Interiors shall be field convertible for top or bottom incoming feed.
8. Main circuit breakers shall be vertically mounted, unless otherwise indicated.
9. Main lug interiors up to 400 amperes shall be field convertible to main breaker.

B. Main Circuit Breakers

1. Main circuit breakers shall have an over-center, trip free, toggle mechanism which will provide quick-make, quick-break contact action. Circuit breakers shall have a permanent trip unit with thermal and instantaneous magnetic trip elements in each pole. Each thermal element shall be true RMS sensing and be factory calibrated to operate in a 40 degrees C ambient environment. Thermal elements shall be ambient compensating above 40 degrees C.
2. Two and three pole circuit breakers shall have common tripping of all poles. Circuit breakers frame sizes above 100 amperes shall have a single magnetic trip adjustment located on the front of the circuit breaker that allows the user to simultaneously select the desired trip level of all poles. Circuit breakers shall have a push to trip button for maintenance and testing purposes.
3. Breaker handle and faceplate shall indicate rated ampacity. Standard construction circuit breakers shall be UL listed for reverse connection without restrictive line or load markings.

C. Branch Circuit Breakers

1. Molded case branch circuit breakers shall have plug-on type bus connectors.

2. Circuit breakers shall have an over-center toggle mechanism which will provide quick-make, quick-break contact action. Circuit breakers shall have thermal and instantaneous magnetic trip elements in each pole. Two and three pole circuit breakers shall have common tripping of all poles.
3. There shall be two forms of visible trip indication. The breaker handle shall reside in a position between ON and OFF. In addition, there shall be a red VISI TRIP indicator appearing in the clear window of the circuit breaker housing.
4. Circuit breakers serving transformers or other load centers shall be equipped with factory-installed, fixed, handle padlock attachment to allow padlocking circuit breakers in the OFF only position.

D. Enclosures

1. Type 1 Enclosures

- a. Boxes shall be galvanized steel constructed in accordance with UL 50 requirements. Galvannealed steel will not be acceptable.
- b. Boxes shall have removable end-walls with knockouts located on one end. Boxes shall have welded interior mounting studs.
- c. Fronts shall meet strength and rigidity requirements per UL 50 standards. Front shall be finished with ANSI 49 gray baked enamel electrodeposited over cleaned phosphatized steel.
- d. Load centers shall have hinged front cover.
- e. Doors on front shall have rounded corners and edges shall be free of burrs.
- f. A clear plastic directory card holder shall be mounted on the inside of the door.

2. Type 3R/5/12 Enclosures

- a. Enclosures shall be constructed in accordance with UL 50 requirements. Enclosures shall be finished with ANSI 49 gray baked enamel electrodeposited over cleaned phosphatized steel.
- b. Doors shall be gasketed and be equipped with a locking vault handle.
- c. A clear plastic directory card holder shall be mounted on the inside of the door.
- d. All lock assemblies shall be keyed alike, one (1) key shall be provided with each lock.

E. Basis of Design – Square D Company, QO Series Load Centers.

PART 3. EXECUTION

3.1. INSTALLATION

- A. Install load centers and accessory items according to NEMA PB 1.1.
- B. Mounting: Plumb and rigid without distortion of box.
- C. Install filler plates in unused spaces.

- D. Wiring in load center gutter: Arrange conductors into groups, and bundle and wrap with wire ties after completing load balancing.
- E. Two 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 load centers as indicated on the Drawings. Ground bus shall be similar in all respects to neutral bus.
- H. Branch circuit breakers (or switches) serving control power circuits shall be equipped with lock clips to prevent accidental operation.

3.2. GROUNDING

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

3.3. 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 step down transformer equipment by means of a removable main bonding jumper. Neutral and ground terminations at one bus bar shall not be acceptable.

3.4. IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section 260553, "Identification for Electrical Systems".
- B. Nameplates: Label each load center with engraved laminated-plastic or metal nameplates as detailed on the Contract Drawings. Refer to Division 26 Section 260553, "Identification for Electrical Systems", for nameplate requirements.
- C. Circuit Directories:
 - 1. Load centers shall have accurate typed circuit directories indicating exactly what each branch circuit serves.
 - 2. The Contractor shall provide up to date circuit directories in new and existing load centers, indicating all deletions and additions, and to note the date of all changes on the directory.
 - 3. The circuit directories shall reflect the actual room numbers. Directories indicating the reference room numbers on the contract drawings or in the load center schedule shall not be acceptable.

4. The circuit directories shall include the name, address, and contact information for the Electrical/Division 26 Contractor.
5. If at any time after occupancy the circuit directories are found to be incorrect due to negligence by the installer, then the Contractor shall trace out circuits, and correct the directories at no additional cost to the Owner.

3.5. FIELD QUALITY CONTROL

A. 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 load center schedules.
2. Clean devices using Manufacturer's approved methods and materials.
3. Verify that load center nameplates are installed and accurate.
4. Verify that phase identification nameplates are installed.
5. Verify that arc flash hazard labels are installed.
6. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
7. Check load center mounting, area clearances, and alignment and fit of components.
8. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
9. Perform visual and mechanical inspection and related work for over-current protective devices.
10. Verify that neutral-ground bonds do not exist at locations that are not service entrances or separately derived power sources.

D. Load Center Electrical Testing: After installing load centers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing. 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.
2. 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.
3. 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.

4. 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.
5. Make continuity tests of each circuit. Refer to Division 26 Section 260519, “Low-Voltage Electrical Power Conductors and Cables” for testing specific to feeder conductors.
6. Perform ground resistance test on system and equipment ground connections
7. Test main and sub-feed overcurrent protective devices.
8. Infrared Scanning: Perform an infrared scan of all electrical connections in each load center, as follows:
 - a. Remove equipment covers so terminations are accessible to scanner.
 - b. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values.
 - c. Provide calibration record for device.
 - d. Compare test results with specified performance or manufacturer’s data. Correct deficiencies identified by tests and retest.
 - e. Prepare reports [certified by testing agency] identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
9. Test Labeling: On satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.
10. Submit all test reports to the Architect for review and approval.
11. Provide copy of all test reports in the O&M manual.

3.6. CLEANING

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

3.7. PROTECTION

- A. Provide final protection and maintain conditions in a manner that shall ensure that the load centers shall be without damage at time of Substantial Completion.

END OF SECTION

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DIVISION 26 SECTION 26 27 16
COMMERCIAL PEDESTALS
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SECTION 26 27 16 – COMMERCIAL PEDESTALS

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. Section includes pad-mounted, weatherproof electrical enclosures with custom configurations of electrical equipment including but not limited to circuit breakers, transformers, load centers, photocells, etc.
- B. Provide all labor, materials, equipment, and services necessary to provide commercial pedestals as indicated herein and on the Contract Drawings.

1.3. RELATED WORK

- A. Division 26 Section 260500, “Common Work Results for Electrical”, for concrete requirements related to concrete bases for commercial pedestals.
- B. Division 26 Section 260526, “Grounding and Bonding for Electrical Systems”, for grounding materials and methods.
- C. Division 26 Section 260543, “Underground Ducts and Raceways for Electrical Systems”, for underground ducts and raceways terminating at commercial pedestals.
- D. Division 26 Section 260553, “Identification for Electrical Systems”, for labeling materials for commercial pedestals.
- E. Division 26 Section 262726, “Wiring Devices”, for receptacles and other wiring devices installed in commercial pedestals.

1.4. QUALITY ASSURANCE

- A. Manufacturer Qualifications: Firm experienced in manufacturing utility structures of types and sizes required and similar to those indicated for this Project. Firm must have a minimum of a 3-year record of successful in-service performance.
- B. Comply with NFPA 70: Electrical Code and ANSI C2 National Electrical Safety Code for components and installation.
- C. 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.

- D. Coordinate layout and installation of pedestals with final arrangement of other utilities as determined in the field.
- E. Coordinate elevations of underground conduit entrances into pedestals with final profiles of conduits as determined by coordination with other utilities and underground obstructions. Revise locations and elevations from those indicated as required to suit field conditions.

1.5. SUBMITTALS

- A. Submit shop drawings and product data under provisions of General Conditions of the Contract and Division 26.
- B. Submit product data for commercial pedestals and accessories. Indicate material specifications, dimensions, capacities, size and location of openings, and accessories.
- C. Submit shop drawings for each commercial service pedestal configuration. Indicate dimensions, device/equipment characteristics and locations.
- D. Submit manufacturer's installation instructions under provisions of General Conditions of the Contract.
- E. 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 Architect and Owner, and other information specified.
- F. Field test reports indicating and interpreting test results relative to compliance with performance requirements of Field Quality Control Article in Part 3 of this Section.

1.6. PROJECT RECORD DOCUMENTS

- A. Submit under provisions Division 26 Section 260500, "Common Work Results for Electrical".
- B. Accurately record actual locations of each commercial pedestal.

1.7. DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect, and handle products to site under provisions of Division 26 Section 260500, "Common Work Results for Electrical".
- B. Accept products on site. Inspect for damage.
- C. Lift and support units only at designated lifting or supporting points.

1.8. COORDINATION

- A. Obtain all available information on underground utilities before starting excavation. If underground utilities interfere with shown location of pedestals, bring this to the attention of the Architect as soon as possible. Pedestal locations shall be revised or relocated only with the approval of the Architect.

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. Commercial Pedestals:
 - a. Milbank Manufacturing (Basis of Design)
 - b. Myers Pedestals
 - c. StrongBox/VIT Products
 - d. Tesco Controls, Inc.

2.2. COMMERCIAL PEDESTALS

- A. Description: Pad-mounted, weatherproof electrical enclosures for site power distribution.
- B. Construction:
1. External construction shall comply with UL50 requirements and shall be of G90 galvanized steel with Federal Specification 595 polyurethane industrial grade powder paint of 1.7 mil minimum thickness, unless otherwise indicated.
 2. Internal construction shall be G90 galvanized steel and 1.7 mil minimum thickness polyurethane industrial grade powder coat painted. No fasteners except sealing screws shall be removable by external access. Hinges shall be stainless steel and of the continuous piano hinge type.
- C. Mounting: The pedestal mounting bolts shall not be externally accessible. The pedestal shall be offered with an optional base designed to be embedded in concrete in place of anchor bolts. Either pedestal mounting base or anchor bolt kit is required for installation.
- D. Features:
1. Compartment door to be hinged on the left-hand side.
 2. A stainless steel pad-lockable hasp provided to secure compartment.
 3. A door keeper provided to keep the door in an open position.
 4. A print pocket on the inside of the door shall hold all wiring schematics, circuit directories and instructions in a clear, weatherproof sleeve.
 5. Required UL labeling shall be located on the inside of the compartment door.
 6. All stainless steel external hardware (screws, bolts, hinges, handles, hasps, and sealing screws).
 7. Distribution and control equipment shall be behind an internal dead-front door with

a quarter-turn securing latch and be hinged to open more than 90 degrees.

8. The dead-front door shall be hinged on the same side as the compartment door.
9. All distribution and control equipment shall be factory wired using 600 volt wire sized to NEC and UL requirements.
- E. Electrical: Pedestals shall contain molded-case circuit breakers, load centers, sealed transformers, and/or lighting control devices as indicated on the Contract Drawings. See Contract Drawings for additional information.
 1. Sealed transformers shall comply with requirements of Division 26 Section 262200, "Low-Voltage Transformers".
 2. Panelboards shall comply with requirements of Division 26 Section 262416, "Panelboards".
 3. Circuit breakers shall comply with requirements of Division 26 Section 262816, "Enclosed Switches and Circuit Breakers".
- F. Ratings: The service pedestal shall be rated for operation at 10K minimum (AIC) amps interrupting capacity. The provided documentation shall list circuit breaker combinations and those to be used for de-rated operation for series ratings. Circuit breakers shall be permanently labeled with engraved name plates.
- G. Finish: Architect shall select finish from standard factory finish options.
- H. Listings: Pedestals shall be of NEMA Type 3R rainproof construction and shall be UL listed as "Enclosed Industrial Control Equipment".

PART 3. EXECUTION

3.1. EXCAVATION

- A. Provide responsibility for all demolition, excavation and backfilling required to install foundations for commercial pedestals.
- B. After completion of pedestal installation, return all ground and pavement surfaces to original condition or to condition as indicated on the drawings. This includes all sidewalks, curbs, streets, parking areas, lawns, shrubs, etc.

3.2. PREPARATION

- A. Excavate, install base material, and compact base material.

3.3. INSTALLATION

- A. Identify pedestals according to Division 26 Section 260553, "Identification for Electrical Systems".
- B. 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.

- C. Install pedestals as indicated on the Drawings, in accordance with Manufacturer's published instructions.
- D. Provide working clearances in conformance with NFPA 70.
- E. Provide minimum 6-inch high concrete pad for outdoor pedestals. Refer to Division 26 Section 260500, "Common Work Results for Electrical", for installation requirements. Use manufacturer-approved mounting brackets for securing pedestals to concrete equipment pads.
- F. Set pedestals plumb and level.
- G. Seal conduits turning up into pedestals with foam duct sealant specified in Division 26 Section 260500, "Common Work Results for Electrical".

3.4. GROUNDING

- A. Comply with Division 26 Section 260526, "Grounding and Bonding for Electrical Systems", for materials and installation requirements.
- B. Provide ground rod(s) for each pedestal as detailed on the Contract Drawings.
- C. Ground and bond separately derived systems (i.e. transformers) per National Electrical Code Article 250.30. Provide supply-side bonding jumper from transformer to first disconnecting means or overcurrent device after the transformer.

3.5. FIELD QUALITY CONTROL

- A. Visual and Mechanical Inspection:
 - 1. Inspect for defects and physical damage, labeling, and compliance with requirements of drawings and schedules.
 - 2. Clean pedestals using Manufacturer's approved methods and materials.
 - 3. Verify that equipment nameplates are installed and accurate.
 - 4. Verify that phase identification nameplates are installed.
 - 5. Verify that arc flash hazard labels are installed.
 - 6. Check mounting, area clearances, and alignment and fit of components.
 - 7. Check tightness of bolted electrical connections with calibrated torque wrench.
 - 8. Refer to manufacturer's instructions for proper torque values.
 - 9. Verify that neutral bar is bonded to ground bar with appropriately sized bonding

jumper.

10. Verify that equipment ground bar is bonded to pedestal enclosure.
 11. Test Labeling: On satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.
- B. Electrical Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
1. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing. 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.
 2. 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.
 3. 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.
 4. 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.
 5. Make continuity tests of each circuit. Refer to Division 26 Section "Conductors and Cables" for testing specific to feeder conductors.
 6. Perform ground resistance test on system and equipment ground connections
 7. Test main and branch over-current protective devices.
 8. Infrared Scanning: Perform an infrared scan of all electrical connections in each pedestal, as follows:
 - a. Remove equipment covers so terminations are accessible to scanner.
 - b. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values.
 - c. Provide calibration record for device.
 - d. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - e. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
 9. Test Labeling: On satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and

person.

10. Submit all test reports to the Architect for review and approval.
11. Provide copy of all test reports in the O&M manual.

3.6. 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.
- B. Remove debris from pedestals and ensure complete installation is left in neat and finished condition.

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DIVISION 26 SECTION 262726
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.
 - 2. GFCI receptacles.
 - 3. Locking receptacles.
 - 4. Tamper-Resistant receptacles.
 - 5. Weather-Resistant receptacles.
 - 6. Toggle switches.
 - 7. Wall-box occupancy sensor switches.
 - 8. Device plates.
 - 9. Cord and plug sets.
 - 10. Retractable cord reels.
 - 11. Emergency pushbuttons.

1.3. DEFINITIONS

- A. GFCI: Ground-Fault Circuit Interrupter.
- B. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- C. PIR: Passive Infrared.
- D. TR: Tamper-Resistant.
- E. US: Ultra- Sonic.
- F. WR: Weather-Resistant.

1.4. SUBMITTALS

- A. Product Data: For each product specified, indicating configurations, finishes, dimensions, and manufacturer's instructions.
- B. 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 C73, Attachment Plugs and Receptacles, Dimensions of.
 - 2. Institute of Electrical and Electronics 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. WD5: Special Purpose Wiring Devices
 - c. WD6: Wiring Devices - Dimensional Requirements.
 - d. WD7: Occupancy Motion Sensors Standard
 - 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 Equipment Furnished with Cord and Plug Sets: Match plug configurations.
- B. Cord and Plug Sets: Match equipment requirements.

1.7. EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Owner.
 - 1. USB Receptacles: One for each ten installed, but not less than two.
 - 2. GFCI Receptacles: One for each ten installed, but not less than two.
 - 3. Wallbox Occupancy Sensor Switches: One for each ten installed, but not less than one of each type.

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 Division
- b. Pass & Seymour/Legrand; Wiring Devices Division
- c. Leviton Manufacturing Co., Inc.
- d. Eaton/Cooper; Wiring Devices Division
- e. Lutron Electronics, Inc.

2. Wall-box Occupancy Sensor Switches:

- a. Actuity/nLight
- b. Watt Stopper
- c. Lutron Electronics, Inc.
- d. Sensor Switch
- e. Hubbell, Inc; Wiring Devices Division
- f. Pass & Seymour/Legrand
- g. Leviton Manufacturing Co, Inc.
- h. Eaton/Cooper; Wiring Devices Division

3. Emergency Pushbuttons:

- a. Safety Technology International, Inc. (STI)
- b. Square D Company
- c. Crouse-Hinds

4. Retractable Cord Reels:

- a. Reelcraft Industries
- b. Hubbell Inc., Wiring Devices Division
- c. Pass & Seymour/Legrand
- d. Ericson Manufacturing Company
- e. Appleton Electric Company
- f. KH Industries

2.2. STRAIGHT BLADE RECEPTACLES

A. General Requirements

1. Straight blade receptacles shall have the following basic features:

- a. One-piece brass mounting strap with integral ground for low resistance of fault currents.
- b. Auto-ground clip to assure positive ground.

- c. Impact-resistant nylon face and thermoplastic base housing.
 - d. #10 large head brass terminal and ground screws; back- and side-wired.
- B. Tamper-Resistant Duplex Convenience Receptacles
 - 1. Tamper-resistant duplex convenience receptacles shall be extra heavy-duty, specification grade, 20A, 125V, with the following features:
 - a. “TR” marking on face as required by UL standard.
 - b. Thermoplastic dual mechanism shutter system to help prevent insertion of foreign objects.
 - 2. Comply with NEMA WD-1, NEMA WD-6 configuration 5-20R, UL 498 and Federal Specification W-C-596.
 - 3. Hubbell HBL5362TR, Pass & Seymour TR63, or approved equal by acceptable manufacturer.
- C. Tamper-Resistant Decorator Duplex Convenience Receptacles
 - 1. Tamper-resistant decorator duplex convenience receptacles shall be extra heavy-duty, specification grade, 20A, 125V, with the following features:
 - a. “TR” marking on face as required by UL standard.
 - b. Thermoplastic dual mechanism shutter system to help prevent insertion of foreign objects.
 - 2. Comply with NEMA WD-1, NEMA WD-6 configuration 5-20R, UL 498 and Federal Specification W-C-596.
 - 3. Hubbell DR20WHITR, Pass & Seymour TR26342, or approved equal by listed manufacturer.
- D. Weather-Resistant Duplex Convenience Receptacles
 - 1. Weather-resistant duplex convenience 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, Federal Specification W-C-596 and 2011 NEC 406.9.
 - 3. Hubbell HBL5362WR, Pass & Seymour WR5362, or approved equal by acceptable manufacturer.
- E. Tamper-Resistant Duplex USB Charger Receptacles
 - 1. Decorator style tamper-resistant duplex convenience receptacles shall be heavy-duty, specification grade, 20A, 125V, with the following features:
 - a. 5Vdc output, minimum 5 amperes

- b. One (1) Type “A” port and one (1) type “C” port
 - c. “TR” marking on face as required by UL standard.
 - d. Thermoplastic dual mechanism shutter system to help prevent insertion of foreign objects.
- 2. Comply with NEMA WD-1, NEMA WD-6 configuration 5-20R, UL 498, UL1310, and Part 15 of FCC regulations.
 - 3. Comply with battery charging specification USB BC1.2.
 - 4. Compatible with USB 2.0/3.0 devices, including Apple® products.
 - 5. Hubbell USB20AC5, Pass & Seymour TR20USBAC6, or approved equal by acceptable manufacturer.

F. Half-Controlled Tamper-Resistant Plug Load Controllable Duplex Receptacles

- 1. Half-controlled tamper-resistant plug load controllable duplex convenience receptacles shall be extra heavy-duty, specification grade, 20A, 125V, with the following features:
 - a. Permanent controlled receptacle marking on one (1) receptacle face, in compliance with 2020 NEC Article 406.3(E), CA Title 24, and ASHRAE Energy Efficiency Standard 90.1.
 - b. Factory-broken split-circuit tab, allowing for half of the receptacle to be controlled.
 - c. “TR” marking on face as required by UL standard.
 - d. Thermoplastic dual mechanism shutter system to help prevent insertion of foreign objects.
- 2. Comply with NEMA WD-1, NEMA WD-6 configuration 5-20R, UL 498 and Federal Specification W-C-596.
- 3. Hubbell HBL5362C1TR, Pass & Seymour TR5362CH Series, or approved equal by acceptable manufacturer.

G. Fully-Controlled Tamper-Resistant Plug Load Controllable Duplex Receptacles

- 1. Fully-controlled tamper-resistant plug load controllable duplex convenience receptacles shall be extra heavy-duty, specification grade, 20A, 125V, with the following features:
 - a. Permanent controlled receptacle marking on each receptacle face, in compliance with 2020 NEC Article 406.3(E), CA Title 24, and ASHRAE Energy Efficiency Standard 90.1.
 - b. “TR” marking on face as required by UL standard.
 - c. Thermoplastic dual mechanism shutter system to help prevent insertion of foreign objects.
- 2. Comply with NEMA WD-1, NEMA WD-6 configuration 5-20R, UL 498 and Federal Specification W-C-596.
- 3. Hubbell HBL5362C2TR, Pass & Seymour TR5362CD Series, or approved equal by acceptable manufacturer.

H. Tamper-Resistant Single Convenience Receptacles

1. Tamper-resistant single convenience receptacles shall be extra heavy-duty, specification grade, 20A, 125V, with the following features:
 - a. “TR” marking on face as required by UL standard.
 - b. Thermoplastic dual mechanism shutter system to help prevent insertion of foreign objects.
 2. Comply with NEMA WD-1, NEMA WD-6 configuration 5-20R, UL 498 and Federal Specification W-C-596.
 3. Hubbell HBL5361TR, Pass & Seymour TR5351, or approved equal by acceptable manufacturer.
- I. 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.

2.3. 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 0.025 seconds (nominal).
 - c. Trip threshold of +/- 5mA.
 - d. Indicator light that is lighted when device is tripped.
 - e. Auto-ground clip to assure positive ground.
 - f. Impact-resistant nylon face and thermoplastic base housing.
 - g. #10 large head brass terminal and ground screws; back- and side-wired.
2. GFCI receptacles shall also have the following functions to comply with UL standard 943:
 - a. An auto-monitoring function that will allow for periodic automatic testing (self-test) of the GFCI device and its ability to respond to a ground fault. If a problem is detected one or more of the following will happen:
 - i. Power will be denied (trip with the inability to reset).
 - ii. Trip with the ability to reset, subject to the next auto-monitoring test cycle or repeatedly trip.
 - iii. Visual and/or audible indication
 - b. Provisions to ensure that receptacle type GFCIs that contain separate line and load terminals, and that is powered through its load terminals, shall not reset and supply power to its receptacle face or line terminals if mis-wired. This applies both during its initial installation and after reinstallation following a correctly wired installation. If the device is provided with special instructions for removal and reinstallation, the instructions shall be followed during testing.

B. Tamper-Resistant Duplex GFCI Receptacles

1. Tamper-resistant duplex GFCI receptacles shall be extra heavy-duty, specification grade, 20A, 125V with the following features:
 - a. “TR” marking on face as required by UL standard.
 - b. Thermoplastic dual mechanism shutter system to help prevent insertion of foreign objects.
2. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, UL 498 and Federal Specification W-C-596.
3. Hubbell GFTRST20, Pass & Seymour 2097TR, or approved equal by acceptable manufacturer.

C. Tamper-Resistant and Weather-Resistant Duplex GFCI Receptacles

1. Tamper-resistant and 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.
 - c. “TR” marking on face as required by UL standard.
 - d. Thermoplastic dual mechanism shutter system to help prevent insertion of foreign objects.
2. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, UL 498 and Federal Specification W-C-596.
3. Hubbell GFTWRST20, Pass & Seymour 2097TRWR, or approved equal by acceptable manufacturer.

D. NEMA 4 Duplex GFCI Receptacles

1. NEMA 4 duplex GFCI receptacles shall be extra heavy-duty, specification grade, 20A, 125V with the following features:
 - a. Protective clear hinged cover and gasketed faceplate
 - b. NEMA 12/4 rated enclosure
 - c. Finger-safe contacts
 - d. Stainless steel snap latch
2. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, UL 498 and Federal Specification W-C-596.
3. Hubbell PR20, 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 L5-20R, 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. Oversized silvery 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, horsepower-rated, 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), Pass & Seymour PS20AC1 (single-pole), PS20AC2 (two-pole), PS20AC3 (three-way), PS20AC4 (four-way), or approved equal by acceptable manufacturer.

C. Illuminated Toggle Switches (Light On with Load Off)

1. Illuminated toggle switches shall be quiet-type, extra heavy-duty, horsepower-rated, industrial grade, 120/277V, 20A, with clear illuminated toggle, lighted with load off.
2. Comply with NEMA WD 1, UL 20 and Federal Specification W-S-896.
3. Hubbell HBL1221ILC (single-pole), HBL1223ILC (three-way), Pass & Seymour PS20AC1-CSL (single-pole), PS20AC3-CSL (three-way), or approved equal by acceptable manufacturer.

D. Pilot Lighted Switches (Light On with Load On)

1. Pilot lighted switches shall be quiet-type, extra heavy-duty, horsepower-rated, industrial grade, 120/277V, 20A, with red illuminated toggle, lighted with load on.
2. Comply with NEMA WD 1, UL 20 and Federal Specification W-S-896.
3. Hubbell HBL1221PL (single-pole), HBL1222PL (two-pole), HBL1223PL (three-way), Pass & Seymour PS20AC1RPL (single-pole), PS20AC2RPL (two-pole), PS20AC3RPL (three-way), or approved equal by acceptable manufacturer.

E. Lockable Switch Handle Guards

1. Provide handle guards with provisions for padlocking at all toggle switches serving as disconnecting means and where indicated on the Drawings.
2. Handle guards shall be steel construction, and shall mount directly over standard switch faceplates.
3. Provide Square D Class 2510 FL1, or approved equal by listed manufacturer.

2.6. WALL-BOX OCCUPANCY SENSOR SWITCHES

- A. Wall switch sensors shall be capable of detection of motion at desk-top level up to 300 square feet, and gross motion up to 1,000 square feet.
- B. Wall switch sensors shall accommodate loads from 0 to 800 watts at 120 volts; 0 to 1200 watts at 277 volts and shall have 180-degree coverage capability.
- C. Sensors shall be dual technology type using a combination of passive-infrared and ultrasonic detection method to distinguish between occupied and unoccupied conditions for area covered.
- D. Sensors shall feature built-in light level sensing for field-adjustable ambient light override.
- E. All sensors shall be capable of operating normally with any electronic ballast and PL lamp systems.
- F. Coverage of sensors shall remain constant after sensitivity control has been set. No automatic reduction shall occur in coverage due to the cycling of air conditioning or heating fans.
- G. All sensors shall have readily accessible, user adjustable controls for time delay and sensitivity. Controls shall be recessed to limit tampering.
- H. Ultrasonic operating frequency shall be crystal controlled to within plus or minus 0.005 percent tolerance to assure reliable performance and eliminate sensor cross-talk. Sensors using multiple frequencies are not acceptable.
- I. All sensors shall provide a method of indication to verify that motion is being detected during testing and that the unit is working.
- J. All sensors shall have no leakage current to load, in manual or in Auto/Off Mode, for safety purposes and shall have voltage drop protection.
- K. All sensors shall have UL rated, 94V-0 plastic enclosures.
- L. Sensor finishes shall match finish of toggle switches as specified herein.

2.7. 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: White.

2. Wiring Devices connected to Computer Power System: Gray.
3. Wiring Devices connected to Emergency Power System: Red.
4. Special Receptacles: Black.
5. Wiring devices located on Stage/Platform: Black.

2.8. DEVICE PLATES

- A. Device plates shall be provided for all switches and receptacles. Device plates shall be as manufactured to fit each 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 Unfinished Spaces: Galvanized steel, unless otherwise noted.
 2. Material for Finished Spaces: 0.04-inch-thick, Type 302, satin-finished stainless steel, except as otherwise indicated.
 3. Material for Stage/Platform: Unbreakable nylon, black finish.
 4. Material for Multi-service Floor Boxes and A/V Wall Boxes: Unbreakable nylon, white finish.
- B. Device plates shall be factory engraved to clearly identify receptacles on GFCI-protected circuits. Lettering shall be ¼" high, filled with black paint and read "GFCI".
- C. Device plates shall be factory engraved to clearly identify receptacles which are on emergency circuits. Lettering shall be ¼" high, filled with red paint and read "EMERGENCY".
- D. Covers for Receptacles and Switches in Damp Locations: Heavy-duty die-cast zinc/aluminum construction with gasketed, hinged lid, listed and labeled for use in "damp locations." All components shall have baked-on electrostatic, polyester, powder paint finish for superior corrosion resistance. Covers 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 receptacles shall comply with NEC Article 406.9(A). Covers for switches shall comply with NEC Article 404.4.
 1. Horizontal Receptacles - Pass & Seymour Model No. CA26H or approved equal by Hubbell, Intermatic or other listed manufacturer.
 2. Vertical Receptacles – Pass & Seymour Model No. CA26V, or approved equal by Hubbell, Intermatic, or other listed manufacturer.
 3. Toggle Switches – Pass and Seymour Model No. CA1, or approved equal.
- E. Covers for Receptacles in Damp and Wet Locations: Heavy-duty die-cast zinc/aluminum construction with hinged lockable lid, designed to be weatherproof while the device is in use, and listed and labeled "extra duty" for use in "wet locations". All components shall have baked-on electrostatic, polyester, powder paint finish for superior corrosion resistance. Covers shall comply with NEC Article 406.9(B).
 1. Duplex/GFCI Receptacles – Pass & Seymour Model No. WIUCAST1 or approved equal by Hubbell, Intermatic, or other listed manufacturer.
- F. Covers for Switches in Damp and Wet Locations: Heavy-duty die-cast zinc/aluminum construction with actuating levers and shall mount directly over the switch. Covers shall comply with NEC Article 404.4 and shall be UL listed for use in wet locations.

1. Toggle Switches – Crouse –Hinds Model No. DS185, or approved equal.
- G. Lockable Covers for Devices in Hard-Use Areas: Brushed 302 stainless steel covers designed for corrosive environments and hard-use areas, with stainless steel springs and keyed cam-style lock.
1. Duplex Receptacles – Pass & Seymour Model WP8-L, or approved equal by Hubbell, or other listed manufacturer.
 2. GFCI Receptacles – Pass & Seymour Model WP26-L, or approved equal by Hubbell, or other listed manufacturer.
 3. Toggle Switches – Pass & Seymour Model WP1-L, or approved equal by Hubbell, or other listed manufacturer.
 4. Network Light Switches - Pass & Seymour Model WP26-L, or approved equal by Hubbell, or other listed manufacturer.

2.9. 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.

2.10. RETRACTABLE CORD REELS

- A. Description: Factory-fabricated retractable cord reel with receptacle connector body and the following features:
1. Corrosion-resistant cast aluminum construction, white powder coat finish.
 2. Factory-assembled, modular type collector ring and brush block assembly.
 3. Lifetime lubricated bearings.
 4. Removable cover(s) for access to springs and ring/brush assembly.
 5. Adjustable, four-roller cord outlet guide.
 6. Built-in cord locking ratchet to hold cord at desired length. Ratchet can be disengaged to provide constant cord tension.
 7. Type SJO cord with conductors to match requirements (voltage, ampacity, quantity) of equipment being connected. 12/3 SJO unless otherwise indicated on the Cord Reel Schedule on the Contract Drawings.
 8. Connector Ends: As indicated on the Cord Reel Schedule on the Contract Drawings, from the following options:
 - a. Single straight blade receptacle, NEMA configuration as noted.
 - b. Single twist-lock receptacle, NEMA configuration as noted.
 - c. One (1) or two (2) 20A duplex receptacles in yellow or black outlet box
 - d. GFCI module and one (1) 20A duplex receptacle in yellow outlet box
 - e. GFCI module and two (2) 20A duplex receptacles in yellow outlet box
 9. Receptacle connector body: Nylon body with integral cable clamping jaws and

blade configuration to match equipment being connected.

- B. Hubbell inREACH Series, or approved equal by listed manufacturer.

2.11. RETRACTABLE CORD REEL ENCLOSURES

- A. Description: Plenum-rated cord reel enclosures shall have the following features:

1. Steel enclosure, white powder coat surface finish, with brackets for mounting with threaded steel rod, and a hinged door with opening for cord reel end.
2. UL 2416 Listed; Compliant with plenum requirements per NEC Article 300.22
3. 75 lbs load capacity
4. 4 inch square electrical box included
5. Pre-punched knockout hole

- B. Provide enclosures for retractable cord reels in the kitchen and other locations as indicated on the Retractable Cord Reel Schedule on the Contract Drawings.

- C. Basis of Design: Hubbell HBLIPRBOX Series.

2.12. EMERGENCY PUSHBUTTONS

- A. 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. Pushbuttons shall include one N.O. and one N.C. contact, unless otherwise indicated on the Contract Drawings.
4. Pushbuttons shall hold up to three (3) sets of isolated contacts.

- B. 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.

- C. 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”

- D. 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.

E. 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.

F. 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.

G. Basis of Design:

- 1. Emergency pushbuttons shall be Stopper Station with Mini Stopper cover, as manufactured by Safety Technology International, Inc. (STI), or approved equal.

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 – GENERAL

- A. Install devices and assemblies plumb, level, and secure.

B. Arrangement of Devices:

1. 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.
2. Exception: Mount exterior GFCI weatherproof duplex receptacles horizontally with grounding terminals on the left, or as required by the local Authority Having Jurisdiction. Group adjacent switches under single, multi-gang wall plates.

C. Protect devices and assemblies during painting.

D. Installation of Device Plates/Covers:

1. Install device plates when painting is complete.
2. Install device plates to suit device type and location.
3. Provide device plates factory engraved “GFCI” for wiring devices protected by a GFCI circuit breaker, e.g. receptacles for electric water coolers and refrigerators.
4. Provide device plates factory engraved “EMERGENCY” for wiring devices served by the emergency power supply system, unless otherwise indicated herein or on the Contract Drawings.
5. Provide damp location covers for wiring devices in damp interior locations, and for floor mounted receptacle outlets in kitchens.
6. Provide wet location covers for wiring devices in exterior locations.
7. Provide lockable hard-use covers for wiring devices in dry interior locations subject to physical damage where security is required, e.g. light switches in gymnasiums.

E. Coordinate cord and plug connected equipment for type and ratings required.

3.3. INSTALLATION – RECEPTACLES

A. All non-locking type, 125 volt, 15 ampere and 20 ampere receptacles installed in the building shall be listed tamper-resistant receptacles in accordance with NEC Article 406.

B. 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 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. Mechanical rooms, electrical rooms, and similar areas where electrical hand tools or portable lighting equipment are to be used.

C. 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.

D. All 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 NEC Article 406.9(A) and 406.9(B) and shall be installed within an enclosure that is weather proof when an attachment plug is inserted.

3.4. INSTALLATION – SWITCHES

- A. Switches shall be located as indicated on the drawings, arranged singular or in gangs within 18" of the door jamb on the strike side of the door openings. Verify the door swings with the Architectural Drawings prior to rough-in.
- B. Install life safety system switches separate from the normal power switches. Do not include in the multiple gang configuration.
- C. All switches in Mechanical Rooms, Electrical Rooms and other such places shall be a lighted handle, single-pole light switch(es).
- D. Emergency shut-down push-buttons for gas-fired equipment shall be provided at all means of egress from rooms in which gas-fired equipment is installed.

3.5. INSTALLATION – WALL-BOX OCCUPANCY SENSOR SWITCHES

- A. Locate and aim sensors in the correct location required for complete and proper volumetric coverage within the range of coverage(s) of controlled areas per the manufacturer's recommendations.
- B. The following areas shall have one hundred (100%) percent coverage for minor (small resolution) motion:
 - 1. Desks in office areas
- C. Arrange a pre-installation meeting with the manufacturer's factory authorized representative, at the Owner's facility, to verify placement of sensors and installation criteria.
- D. Proper judgment must be exercised in executing the installation so as to ensure the best possible installation in the available space and to overcome local difficulties due to space limitations or interference of structural components. Provide, at the Owner's facility, the training necessary to familiarize the Owner's personnel with the operation, use, adjustment, and problem-solving diagnosis of the occupancy-sensing devices and systems.
 - 1. Sensors installed in damp locations such as near showers, in wet locations, or where exposed to rain shall be equipped with watertight/weatherproof enclosure.
 - 2. Mounting of passive infrared and dual technology sensors where columns, doors, walls, or other obstructions will block the sensor's field of view should be avoided.
 - 3. Passive infrared coverage should not extend through doorways. Masking inserts shall be installed for PIR coverage rejection to prevent false tripping.
- E. Install system components in accordance with Manufacturer's instructions. Sensor locations are approximate and are designed according to the specified manufacturer.
- F. Sensors shall be positioned so that lights are activated when a person is 2 feet or less

through any doorway.

- G. Prior to energizing circuits, wiring shall be tested for electrical continuity and short circuits to ensure proper polarity of connections is maintained.

3.6. IDENTIFICATION

- A. Comply with Division 26 Section 260553, “Identification for Electrical Systems”.
 - 1. Switches: Switches shall be labeled as to lights/load controlled and with circuit number and panel identification.
 - 2. Receptacles: All device plates shall be labeled to 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. Labels shall be clear with black lettering. 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.
 - 5. Faceplate labels shall be installed such that they are readable and do not cover any portion of the faceplate securing screw(s) or the wiring device itself.
 - 6. Faceplate labels for exterior receptacle outlets shall be on the inside of the weatherproof covers.

3.7. 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.

3.8. 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.

3.9. CLEANING

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

END OF SECTION

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DIVISION 26 SECTION 26 27 43
ELECTRIC-VEHICLE SERVICE EQUIPMENT
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SECTION 26 27 43 - ELECTRIC-VEHICLE SERVICE EQUIPMENT

PART 1. GENERAL

1.1. RELATED DOCUMENTS

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

1.2. SUMMARY

- A. Section includes EVSE that provides AC Level 1 and Level 2 EV charging.

1.3. DEFINITIONS

- A. EV: Electric vehicle.
- B. EV Cable: The off-board cable containing the conductor(s) to connect the EV power controller to the EV that provides both power and communications during energy transfer.
- C. EV Charger or EV Charging Equipment: See "EVSE."
- D. EV Connector: A conductive device that, when electrically coupled to an EV inlet, establishes an electrical connection to the EV for the purpose of power transfer and information exchange. This device is part of the EV coupler.
- E. EV Coupler: A mating EV inlet and connector set.
- F. EV Inlet: The device in the vehicle into which the EV connector is inserted, and a conductive connection is made for the transfer of power and communication. This device is part of the EV coupler.
- G. EVSE: Electric-Vehicle Supply Equipment. It includes the EV charging equipment and conductors, including the ungrounded, grounded, and equipment grounding conductors and EV cables, attachment plugs, and all other fittings, devices, power outlets, or apparatus installed specifically for transferring energy between the premise wiring and the EV.

1.4. PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5. ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for EV charging equipment.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For EVSE.

1. Include plans, elevations, sections, and mounting attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of mounting assemblies for EV charging equipment.
4. Include diagrams for power, signal, and control wiring.
5. Include verification of communications service at each location of EVSE.

C. Product Schedule: For EVSE. Use same designations indicated on Drawings.

1.6. INFORMATIONAL SUBMITTALS

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

1. Structural members to which equipment will be attached.
2. Electrical service.
3. Communications service, including wireless communications equipment.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's warranty.

1.7. CLOSEOUT SUBMITTALS

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

B. Software and Firmware Operational Documentation:

1. Software operating manuals.
2. Program Software Backup: On USB, CD, Cloud, or approved media, complete with configuration files.
3. Device address and password list.
4. Printout of software application and graphic screens.

1.8. MAINTENANCE MATERIAL SUBMITTALS

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

1.9. QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.10. FIELD CONDITIONS

A. Wireless Survey: Complete wireless survey to determine if wireless provider signals meet

or exceed manufacturer's recommended minimum values.

- B. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not exceeding minus 22 to plus 122 deg F (minus 30 to plus 50 deg C).
 - 2. Altitude: Not exceeding 6600 feet (2000 m).
- C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Architect no fewer than two days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Architect's written permission.

1.11. WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components of EVSE that fail(s) in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Source Limitations: Obtain EVSE from single manufacturer.

2.2. PERFORMANCE REQUIREMENTS

- A. Ambient Temperature: 5 to 104 deg F (Minus 15 to plus 40 deg C).
- B. Relative Humidity: Zero to 95 percent.
- C. Altitude: Sea level to 1000 feet (300 m).
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
- E. Surge Withstand: 6 kV at 3000 A.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- G. EV Charging Levels:
 - 1. Single vehicle, AC Level 1 at up to 1.7 kW per vehicle.
 - 2. Single vehicle, AC Level 2 at up to 19.2 kW per vehicle.

3. Dual vehicles, AC Level 2 at up to 19.2 kW per vehicle.

2.3. EVSE DESCRIPTION

- A. Comply with NFPA 70.
- B. Comply with:
 1. UL 2231-1.
 2. UL 2594.
 3. SAE J1772 for SAE combo chargers.
 4. CHAdeMo for CHAdeMo chargers.
- C. Comply with ADA-ABA Accessibility Guidelines.
- D. Metering: Nonrevenue grade meter.
- E. Control Power: 20 A, 110/120-V ac, 60 Hz, single phase per charger.
- F. Input Power:
 1. 20 A, 110/120-V ac, 60 Hz, single phase per charger.
 2. Two 40 A, 208/240-V ac, 60 Hz, single-phase services per charger.
 3. Dual circuits shall be interlocked.
- G. Integral GFCI.
- H. Auto-GFCI fault retry.
- I. EVSE Mounting: Bollard mount/Pedestal mount as indicated on Drawings.
- J. Enclosures:
 1. Rated for environmental conditions at installed location.
 - a. Outdoor Locations: NEMA 250, Type 3R.
 - b. Stainless steel.
 - c. Thermoset, polyester powder paint.
 - d. Lockable.
 - e. Tamper resistant.
- K. EV Cable and Connectors:
 1. SAE J1772 connector.
 2. Double connectors with locking holster.
 3. 10-foot (3-m) cable with cable management system.
 4. Field-replaceable connector and cable assembly.
- L. Status Indicators:
 1. LEDs to indicate power, charging, charging complete, system status, faults, and

service.

M. Display Screen:

1. Daylight viewable, UV-protected display with human-machine interface capability.
2. Displays power, charging, charging complete, remote control, system status, faults, and service.

N. Networking:

1. WAN Communications: Cellular GSM/GPRS.
2. LAN Communications: 10/100/1000 Base T Ethernet.
3. Capable of remote configuration and reporting.

O. Charging Network: Compatible with the Manufacturer's EV charging network.

1. Multiple units shall independently connect to charging network.
2. Multiple units shall have one unit designated as a master unit that is configured as a gateway unit between the EVSE and the charging network.
3. Individual units shall be capable of indicating station status and availability.

2.4. GENERAL FINISH REQUIREMENTS

- A. Protect mechanical finishes on exposed surfaces from damage by utilizing cushioning materials or foam or by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3. EXECUTION

3.1. EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for EVSE electrical conduit to verify actual locations of conduit connections before equipment installation.
- C. Examine pavement for suitable conditions where EVSE will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. INSTALLATION

- A. Comply with NECA 1 and NECA 413.
- B. Concrete Base Mounting:

1. Install EVSE on 6-inch (150-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - a. 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.
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - e. Secure EVSE to concrete base according to manufacturer's written instructions.
 2. Install EVSE on 12-inch (300-mm) nominal-diameter and 48-inch- (1200-mm-) deep concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - a. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - b. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - c. Secure EVSE to concrete base according to manufacturer's written instructions.
- C. Wall Mounting:
1. Install EVSE, so that its receptacles or holders are not less than 18 inches (450 mm) and not more than 4 feet (1.2 m) above finished floor.
 2. Mount EVSE to steel slotted supports [5/8 inch (16 mm)] [1-1/4 inches (32 mm)] in depth. Orient steel slotted supports vertically.
 3. Ensure that EVSE is plumb and rigid without distortion of box.
 4. Secure EVSE according to manufacturer's written instructions.
- D. Pole Mounting:
1. Allow a minimum of 24 inches (600 mm) of clearance around EVSE.
 2. EVSE receptacles or holders shall be not less than 24 inches (600 mm) and not more than 4 feet (1.2 m) above finished grade.
 3. Mount EVSE plumb and rigid without distortion of enclosure.
 4. Secure EVSE according to manufacturer's written instructions.
- E. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- F. Wiring Method: Install cables in raceways and cable trays. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
 2. Comply with requirements for underground raceways and enclosures specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems."
- G. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- H. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- I. Disconnect: Install disconnect in a readily accessible location according to Section 262816 "Enclosed Switches and Circuit Breakers."
- J. Circuit Breakers: Comply with Section 262816 "Enclosed Switches and Circuit Breakers."
- K. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking from enclosures and components.
- L. Secure covers to enclosure.
- M. Cybersecurity:
1. Software:
 - a. Coordinate security requirements with IT department.
 - b. Ensure that latest stable software release is installed and properly operating.
 - c. Disable or change default passwords to password of at least eight characters in length, using a combination of uppercase and lower letters, numbers, and symbols. Record passwords and turn over to party responsible for system operation and administration.
 2. Hardware:
 - a. Coordinate location and access requirements with IT department.
 - b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
 - c. Disable dual network connections.

3.3. CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Comply with grounding requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Comply with requirements for installation of conduit in Section 260533 "Raceways and Boxes for Electrical Systems." Drawings indicate general arrangement of conduit, fittings,

and specialties.

- 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-486B.
- E. Verify that all electrical connections have been made according to the manufacturer's instructions. Remove all burrs, shavings, and detritus from inside the enclosure.
- F. After confirming all connections, install covers and tighten fasteners to according to manufacturer's instructions.

3.4. IDENTIFICATION

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

3.5. 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. Perform tests and inspections with the assistance of a factory-authorized service representative.
- C. Tests and Inspections:
 - 1. For each unit of EVSE, perform the following tests and inspections:
 - a. Unit self-test.
 - b. Operation test with load bank.
 - c. Operation test with EV.
 - d. Network communications test.
- D. EVSE will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.6. STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.7. SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and

program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.8. DEMONSTRATION

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

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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.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 26 Section 260553, “Identification for Electrical Systems”, for labeling materials.
 - 2. Division 26 Section 262816, “Enclosed Switches & Circuit Breakers”, for enclosed fusible disconnect/safety switches.
 - 3. Division 26 Section 262913, “Enclosed Controllers”, for enclosed motor controllers with fusible disconnect/safety switches.

1.2. SUMMARY

- A. This Section includes the following:
 - 1. Cartridge fuses rated 600Vac and less for use in the following:
 - a. Control circuits.
 - b. Enclosed controllers.
 - c. Enclosed switches.
 - 2. Spare fuse cabinets.
- B. The Electrical Contractor shall provide a complete set of fuses for all fusible 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. ACTION 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 type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets.

Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in PDF format.
5. Coordination charts and tables and related data.

1.5. CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuses to include in Operation and Maintenance manuals. In addition to items specified under Division 01, include the following:
 1. Ambient temperature adjustment information.
 2. Current-limitation curves for fuses with current-limitation characteristics.
 3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in PDF format.
 4. Coordination charts and tables and related data.
- B. Record Drawings: Record the equipment nameplate rating and actual fuse rating and location of fuses on the record drawings.

1.6. MAINTENANCE MATERIAL SUBMITTALS

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

1.7. QUALITY ASSURANCE

- A. Comply with NFPA 70 for components and installation.
- B. 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. 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.
4. Comply with NFPA 70.
5. Comply with National Electrical Manufacturer's Association NEMA FU-1 Low Voltage Cartridge Fuses.
6. Comply with IEC269.
7. Comply with CANENA Standard 248.
8. Comply with UL 198.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering fuses that may be incorporated into the Work include, but are not limited to, the following:
 1. Bussmann; Eaton Corporation
 2. Littelfuse, Inc.
 3. Mersen (formerly Ferraz Shawmut)
- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2. CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
- B. Fuses shall feature a solid state visual open fuse indicator, metal-embossed date and catalog number for identification.
- C. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3. SPARE FUSE CABINETS

- A. Description: Wall-mounted, locking utility cabinet(s) with hinged door and shelves for spare fuses.
- B. Construction: 16 or 14 gauge steel, ANSI 61 gray polyester powder paint finish inside and out.
- C. Dimensions: Cabinet shall be of proper size for orderly storage of spare fuses and fuse pullers stored in the same, plus space for 15 percent spare capacity.
- D. Fuse Pullers: Provide one (1) fuse puller for each size and type fuse stored in each spare

fuse cabinet.

- E. Basis of Design: Provide shelf style locking utility cabinets as manufactured by Hoffman/Pentair, or approved equal by Cooper/Bussman.

PART 3. EXECUTION

3.1. EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. FUSE APPLICATIONS

- A. Main Service and Feeders 600A and Greater: Class L, fast acting, 600 Volt, 601-6000 Amp, and 300 kA interrupting rating. 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.
- B. Main Service and Feeders Less than 600A: Class J, time delay, 600 Volt, 0-600 Amp, and 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.
- C. Motor Branch Circuits: Class RK1, time delay, 250 Volt or 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.
 - 1. The following guidelines apply for motors protected by properly sized overload relays:
 - a. 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.
 - b. 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.

2. The following guidelines apply where fuses are used as the only overload protection for the motor:
 - a. For motors with a 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).
 - b. 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).
 3. Fuse sizes for motor protection shall be chosen from fuse manufacturers published data and recommendations.
- D. 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-level 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.
- E. Other Branch Circuits: Class RK1, non-time delay, 250 Volt or 600 Volt, 0-600 Amp, and 300 kA interrupting rating.
- F. Control Circuits: Class CC, current limiting rejection type, rated 0-30 amperes, 600 volts, and 200- kA interrupting rating.
- G. Provide fuses of type and rating recommended by equipment manufacturer for packaged and/or specialized equipment.

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.
- B. All fuses shall be furnished and installed by the electrical contractor. All fuses shall be of the same manufacturer.
- C. Install fuses in fusible devices as indicated. Arrange fuses so fuse ratings and open fuse indicators are visible without removing fuses.
- D. Provide fuse clips as required.
- E. Provide spare fuse cabinet(s) in the main electrical room and in each mechanical room. Cabinet(s) shall be mounted 5’-6” to top unless otherwise noted on the Contract Drawings.

3.4. IDENTIFICATION

- A. Identification: Provide engraved nameplate to read “SPARE FUSES” in 1/2" high lettering on front door of cabinet(s). Refer to Division 26 Section 260553, “Identification for Electrical Systems”, for nameplate requirements.

END OF SECTION

DIVISION 26 SECTION 26 28 16
ENCLOSED SWITCHES & CIRCUIT BREAKERS
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SECTION 26 28 16 – ENCLOSED SWITCHES & 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.
- B. Related Sections include the following:
 - 1. Division 26 Section 262813, “Fuses”, for fuses in enclosed fusible disconnect switches.

1.2. SUMMARY

- A. This Section includes individually mounted disconnect switches and circuit breakers used for the following:
 - 1. Equipment disconnect switches.
 - 2. Feeder disconnect switches.
 - 3. Motor disconnect switches.
- B. Provide method of disconnection at all appliances, motors, equipment, etc., as required to comply with NEC (including Article 422-C, and Article 440-D).

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 disconnect 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.
- C. Submit a schedule of equipment to indicate ratings of disconnects, fuses, circuit breakers, and other electrical characteristics for each item of equipment.
- D. Maintenance data for disconnect switches and circuit breakers to include in the operation and maintenance manual specified in Division 01.
- E. Field test reports indicating and interpreting test results.

1.4. QUALITY ASSURANCE

- A. Testing Agency Qualifications: In addition to the 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 (NETA).

1. Testing Agency's 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.

1.5. 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. 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. Manufacturers: Subject to compliance with requirements, provide equipment from one of the following manufacturers; no other manufacturers are acceptable.
 1. Disconnect/Safety Switches:
 - a. Square D Company. (Basis of Design)
 - b. Eaton Corp.; Cutler Hammer.
 - c. Siemens Energy & Automation, Inc.
 - d. General Electric (GE)
 2. Enclosed Circuit Breakers:
 - a. Square D Company. (Basis of Design)
 - b. Eaton Corporation; Cutler Hammer.

- c. Siemens Energy & Automation, Inc.
- d. General Electric (GE)

2.2. DISCONNECT SWITCHES

- A. Enclosed, Non-fusible Switch: Heavy duty, NEMA KS 1, Type HD, with lockable handle 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.
- B. Enclosed, Fusible Switch, 800 A and Smaller: Heavy duty, NEMA KS 1, Type HD, clips to accommodate specified fuses, fuse pullers, 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. Enclosures: 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, Type 304 stainless steel, attached by molded hinges and stainless steel hinge pins.

2.3. ENCLOSED CIRCUIT BREAKERS

- A. Enclosed, Molded Case Circuit Breakers: 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, 250 Ampere Frame and Smaller: Factory sealed thermal magnetic trip units.
- E. Circuit Breakers, 400 Ampere Frame and Larger: Electronic trip units with 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: As indicated.

- 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.
- J. Provide full capacity neutral lug or 200 full capacity neutral for non-linear loads and equipment grounding lug.

PART 3. EXECUTION

3.1. INSTALLATION

- A. Install disconnect switches and circuit breakers in locations as indicated, according to manufacturer's written instructions.
- B. Install disconnect switches and circuit breakers level and plumb. Provide mounting brackets, wall bracing, and accessories as required.
- C. Install disconnect switches and circuit breakers to have adequate working space in accordance with Article 110.26 of the National Electrical Code. Disconnect switches and circuit breakers shall not be installed beneath ductwork, piping, etc.
- D. Install wiring between disconnect switches, circuit breakers, and associated control and indication devices.
- E. Provide fuses for all fusible safety switches as indicated and required by the load being served. Coordinate fuse ratings with mechanical equipment electrical characteristics.
- F. 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.
- G. Weatherproof enclosures shall be provided for all disconnect switches and circuit breakers exposed to the elements whether called for or not.
- H. Disconnect 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.
- I. Install disconnect switches and 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. CONNECTIONS

- A. Connect disconnect switches and circuit breakers and components to wiring system and to

ground as indicated and instructed by manufacturer.

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

3.3. IDENTIFICATION

- A. Identify each disconnect switch and circuit breaker according to requirements specified in Division 26 Section 260553, "Identification for Electrical Systems". All switches shall be provided with engraved nameplates which clearly identify the equipment served, circuit designation, and circuit voltage/phase.
- B. Each disconnect means shall be legibly marked as required by Code (including integral disconnect units furnished with motors, appliances, feeders, and branch(es)).

3.4. FIELD QUALITY CONTROL

- A. Visual and mechanical inspection: Include the following inspections and related work.
 - 1. 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.
 - 7. Verify that fuses are facing out and that fuse ratings and blown fuse indicators are visible without removing fuses.
- B. Electrical Tests: Upon installation of disconnect switches and enclosed circuit breakers and before electrical circuitry has been energized, provide the following minimum inspections and tests according to manufacturer's written instructions to ensure components are operational within industry and manufacturer's tolerances, are installed according to the Contract Documents, and are suitable for energizing.
 - 1. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing. 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.
 - 2. Inspect accessible components for cleanliness, mechanical and electrical integrity, and damage or deterioration.
 - 3. 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.

4. NETA Testing:
 - a. 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.
 - b. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - c. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
5. Infrared Scanning: Perform an infrared scan of each disconnect switch and enclosed circuit breaker, as follows:
 - a. Remove equipment covers so terminations are accessible to scanner.
 - b. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values.
 - c. Provide calibration record for device.
 - d. Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest.
 - e. Prepare reports certified by testing agency identifying equipment checked and describing results of tests. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
6. Test Labeling: On satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.

3.5. ADJUSTING

- A. Adjust/replace fuses in disconnect switches if required to properly coordinate with overcurrent protection requirements of equipment served and with upstream and downstream protective devices.
- B. Set field adjustable circuit breaker trip ranges as recommended in overcurrent protection coordination study specified in Division 26 Section 260573, "Power System Studies".

3.6. 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.

END OF SECTION

DIVISION 26 SECTION 26 29 13
ENCLOSED CONTROLLERS
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SECTION 26 29 13 - ENCLOSED 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.
- B. Related Sections include the following:
 - 1. Division 26 Section 260500, “Common Work Results for Electrical”, for Mechanical - Electrical coordination requirements.
 - 2. Division 26 Section 260500, “Common Work Results for Electrical”, for general materials and installation methods.
 - 3. Division 26 Section 260553, “Identification for Electrical Systems”, for labeling materials.
 - 4. Division 26 Section 262813, “Fuses”, for fuses installed in combination magnetic motor controllers with fusible disconnect switches.

1.2. SUMMARY

- A. This Section includes AC motor-control devices rated 600 V and less that are supplied as enclosed units.

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. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- C. Maintenance Data: For products to include in the operation and maintenance manuals specified in Division 01.
- D. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- E. Submit a schedule of equipment to indicate motor controller ratings, sizes, and other

electrical characteristics for each item of equipment.

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 repairs.
- B. Source Limitations: Obtain similar motor-control devices through one source from a single manufacturer.
- C. Comply with NFPA 70.
- D. 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.
- E. UL Compliance: NEMA ICS 2, 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.

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 ratings 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 in 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. Motor 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 in the conduit fittings on the motors, the final connection being made with flexible metal conduit (FMC) in dry locations and with Liquid-Tight Flexible Metal Conduit (LFMC) in damp/wet locations.
- 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 in 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. 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. 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.

1.10. 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. Overload Relays: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2. Pilot Lights: Equal to 10 percent of quantity installed for each type, but no fewer than two of each type. Where lamps are field replaceable, furnish spare lamps only.
 - 3. Fuses for Fusible Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 4. 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.
 - 5. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.

6. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, supply equipment from one of the following manufacturers. No other manufacturers are acceptable.
 1. Square D Company; Groupe Schneider. (Basis of Design).
 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.
 6. General Electric (GE).
- 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 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. Dry/Interior Locations: Motor controllers shall have ANSI/NEMA ICS 6, Type 1 enclosures. Provide flush-mounted enclosures for units located in finished areas. Provide handle guard with locking provisions in the "off" position on all enclosures. Provide Square D, Class 2510 Type F motor controllers with 2510 FL1 handle guard, or approved equal for dry, interior locations.
- D. Damp/Wet Locations: Motor controllers shall have ANSI/NEMA ICS 6, Type 4 water-tight and dust tight die-cast zinc enclosures. Provide Square D, Class 2510 Type FW motor controllers and Square D 9001SKY111 control station with Hand-Off-Auto label plate, or approved equal.

2.3. MANUAL MOTOR SWITCHES

- A. Description: NEMA ICS 2, AC general-purpose Class A manually-operated, full-voltage controller for integral horsepower induction motors, without thermal overload unit. Manual motor switches shall be equipped with toggle operator. Provide size and number of poles as required for a complete installation of the equipment being connected.

- B. Dry/Interior Locations: Motor switches shall have ANSI/NEMA ICS 6, Type 1 enclosures. Provide flush-mounted enclosures for units located in finished areas. Provide handle guard with locking provisions in the "off" position on all enclosures. Provide Square D, Class 2510 Type K motor switches with 2510 FL1 handle guard, or approved equal.
- C. Damp/Wet Locations: Motor controllers shall have ANSI/NEMA ICS 6, Type 4 water-tight and dust tight die-cast zinc enclosures. Provide Square D, Class 2510 Type KW motor switches, or approved equal.

2.4. COMBINATION MAGNETIC MOTOR CONTROLLERS

- A. Description: Combine magnetic motor controllers with fusible switch disconnect 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. Fusible Switch Assemblies: NEMA KS 1, enclosed knife switch with externally operable handle and visible blades. Switch shall have a color-coded externally operated handle. Operating handle shall give positive visual indication of "on/off" with red and black color-coding. Switch shall have fuse clips to accept rejection-type, dual-element, current-limiting, time-delay fuses, as specified in Division 26 Section "Fuses".
- 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. Solid State: Trip current rating will be established by selection of overload relay and shall be adjustable (3 to 1 current range). The overload shall be self-powered, provide phase loss and phase unbalance protection, have a permanent tamper guard, and be ambient insensitive. It shall be available in Trip Class 10 or Class 20 and have a mechanical test function.
 - 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. Provide fused secondary protection and bond un-fused leg of secondary to enclosure.
2. Auxiliary Contacts: Provide two normally open (N.O.) and two normally closed (N.C.) auxiliary contacts in each starter in addition to the standard normally open (N.O.) sealing contact.
3. Selector Switches: Rotary type, Hand-Off-Automatic (H-O-A) selector switch. All switch positions shall be maintained contact.
4. Cover Mounted Indicating Lights: Green "Power Available" and red "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. Control Relays: Auxiliary and adjustable time-delay relays.

J. Furnish Square D, Class 8538 Type S, or approved equal.

2.5. ENCLOSURES

- A. Description: All motor controllers shall be mounted in enclosures, flush or surface mounted as required. Provide flush-mounted enclosures for motor controls in finished locations.
- B. Enclosures shall comply with requirements of NEMA 250 – “Enclosures for Electrical Equipment”, and NEMA ICS 6 – “Enclosures Standard”.
- C. Enclosures shall be provided in accordance with the following requirements in order to meet environmental conditions at the installed location of each motor controller.
 1. Dry, Interior Locations: NEMA Type 1.
 2. Damp or Wet Locations: NEMA Type 3R.
 3. Kitchen Areas: NEMA Type 4X, Stainless Steel.

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. Provide fractional-horsepower manual motor controllers for single-phase motors, unless otherwise indicated.
- D. Provide combination magnetic motor controllers for three-phase motors, unless otherwise

indicated.

- E. Hand-Off-Automatic Selector Switches: In covers of motor controllers started and stopped by automatic controls or interlocked with other equipment.
- F. Provide heaters and/or fuses correlated with full load nameplate current of motors provided. Set adjustable overload devices to suit motor provided.
- G. 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 motor controller. This provides “no damage” protection for the motor controller, under low and high level fault conditions, as required by IEC Publication 947-4.

3.2. INSTALLATION

- A. Install motor controllers in locations as indicated, according to manufacturer's written instructions.
- B. Install motor controllers level and plumb. Provide mounting brackets, wall bracing, and accessories as required.
- C. Install motor controllers to have adequate working space in accordance with Article 110.26 of the National Electrical Code. Motor controllers shall not be installed beneath ductwork, piping, etc.
- D. Install independently mounted motor-control devices according to manufacturer's written instructions.
- E. Location: Locate controllers within sight of motors controlled, unless otherwise indicated.
- F. 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 260529, “Hangers and Supports for Electrical Systems”.

3.3. IDENTIFICATION

- A. Identify motor-control components and control wiring according to requirements specified in Division 26 Section 260553, “Identification for Electrical Systems”.
- B. All motor controllers shall be provided with engraved nameplates which clearly identify the equipment served, circuit designation, and circuit voltage/phase.

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.

3.5. CONNECTIONS

- A. Connect motor controllers and components to wiring system and to ground as indicated and instructed by manufacturer.
- B. 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 486B.

3.6. FIELD QUALITY CONTROL

- A. Visual and Mechanical Inspection: Include the following inspections and related work.
 - 1. Inspect for defects and physical damage, NRTL labeling, and nameplate compliance with drawings and schedules.
 - 2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instructions.
 - 3. Check tightness of electrical connections of devices with calibrated torque wrench. Use Manufacturer's recommended torque values.
 - 4. Clean devices using Manufacturer's approved methods and materials.
 - 5. Verify proper fuse types and ratings in fusible devices.
 - 6. Verify that fuses are facing out and that fuse ratings are readable without removing fuses.
 - 7. Verify proper overload types and ratings in devices with overload protection.
 - 8. Verify proper operation of pilot lights.
 - 9. Verify proper operation of hand-off-automatic selector switches.
 - 10. 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.

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 motor controllers and train Owner's maintenance personnel.
 - 1. Conduct a minimum of 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 7 days' advance notice.

END OF SECTION

Smyrna School District
Smyrna, Delaware

Sunnyside Intermediate School – New School
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DIVISION 26 SECTION 26 32 13
ENGINE GENERATORS
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SECTION 26 32 13 - ENGINE GENERATORS

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. Related Sections include the following:
 - 1. Division 26 Section 260500, "Common Work Results for Electrical", for requirements for concrete equipment pads for engine generators.
 - 2. Division 26 Section 262418, "Load Centers", for requirements for load centers in engine-generator sets.
 - 3. Division 26 Section 263600, "Transfer Switches", for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.2. SUMMARY

- A. This Section includes packaged engine-generator sets for a Class 48, Type 10, Level 1 emergency power supply system with the following features:
 - 1. Diesel engine.
 - 2. Unit-mounted cooling system.
 - 3. Unit-mounted control and monitoring.
 - 4. Starting battery and battery charger.
 - 5. Muffler and exhaust piping.
 - 6. Remote annunciator.
 - 7. Outdoor enclosure.

1.3. DEFINITIONS

- A. Class: The minimum amount of hours that the EPSS can operate at its rated load without being re-fueled. For example, a Class 48 system must operate for a minimum of 48 hours.
- B. Emergency Systems: Systems legally required and classed as emergency by municipal, state, federal or other codes, or by any governmental agency having jurisdiction, which are intended to automatically supply illumination, power, or both, to designated areas and equipment in event of failure of the normal power supply.
- C. EPSS: Emergency power supply system.
- D. Level: There are two Levels defined by NFPA 110 for an EPSS. Level 1 is more stringent and is imposed when failure of EPSS equipment could result in loss of human life or serious injuries. Level 2 is used when failure of the EPSS is less critical to human life and safety.
- E. NFPA: National Fire Protection Association.

- F. Operational Bandwidth: The total variation from the lowest to the highest value of a parameter over a range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
- G. SPSS: Standby power supply system
- H. Standby Rating: Power output rating equal to the power the generator set delivers continuously under normally varying load factors for the duration of a power outage.
- I. Steady-State Voltage Modulation: The uniform cyclical variation of voltage within the operational bandwidth, expressed in hertz (Hz) or cycles per second.
- J. Type: The maximum amount of seconds that the load terminals of the EPSS transfer switch can be without acceptable electrical power. For example, a Type 10 EPSS must provide electrical power within 10 seconds.

1.4. SUBMITTALS

- A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
 - 1. Thermal damage curve for generator.
 - 2. Time-current characteristic curves for generator protective device.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
 - 2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
 - 4. Wiring Diagrams: Power, signal, and control wiring. Differentiate between factory-installed and field-installed wiring.
- C. Source quality-control test reports.
 - 1. Certified summary of prototype-unit test report.
 - 2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 - 3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
 - 4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
 - 5. Report of sound generation.
 - 6. Report of exhaust emissions showing compliance with applicable regulations.

7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
- D. Field quality-control test reports.
- E. Warranty: Special warranty specified in this Section.
- F. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section, "Operation and Maintenance Data," include the following:
 1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

1.5. EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fuses: One for every 10 of each type and rating, but no less than one of each.
 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
 4. Belts: Two sets of each type.

1.6. QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 1. Maintenance Proximity: Not more than four hours' normal travel time from installer's place of business to Project site.
 2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles (321 km) of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- D. 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.
- E. Comply with ASME B15.1.
- F. Comply with NFPA 37.

- G. Comply with NFPA 70.
- H. Comply with NFPA 110 requirements for emergency power supply system level specified.
- I. Comply with UL 2200.
- J. Comply with ISO 8528.
- K. Engine Exhaust Emissions:
 - 1. Comply with EPA Tier 3 requirements and all applicable state and local government requirements.
 - 2. Generators shall be factory certified to meet Environmental Protection Agency (EPA) New Source Performance Standards (NSPS).
 - 3. Obtain DNREC air quality permit-to-construct for generator equipment, as required.
- L. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.
 - 1. Refer to generator schedule on the Contract Drawings for maximum noise level (dBA value).

1.7. PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Architect, Construction Manager, and Owner no fewer than seven days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Architect's, Construction Manager's, and Owner's written permission.
- B. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: Minus 15 to plus 40 deg C.
 - 2. Relative Humidity: 0 to 95 percent.
 - 3. Altitude: Sea level to 1000 feet (300 m).

1.8. COORDINATION

- A. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and form-work requirements are specified in Division 03 Section, "Cast-in-Place Concrete".

1.9. WARRANTY

- A. Special Warranty: Manufacturer's comprehensive warranty in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period, including but not limited to materials, labor, travel, fuel, lodging, etc.

1. Warranty Period: Five years from date of Substantial Completion.

1.10. MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 60 months' full maintenance by skilled employees of manufacturer's designated service organization.

1. Provide quarterly multi-point operational inspection including the following at a minimum:
 - a. Check all belts, adjust as needed.
 - b. Check rubber hoses, replace as needed.
 - c. Inspect cooling system and test antifreeze.
 - d. Inspect air filters.
 - e. Inspect block heater for proper operation.
 - f. Check lube oil level and top off all fluids.
 - g. Inspect/test fuel system.
 - h. Inspect battery/cables/connections.
 - i. Inspect exhaust system.
 - j. Check engine ignition components.
 - k. Test run system and check voltage and frequency.
 - l. Exercise generator to check for proper starting, load transfer, and running under load.
2. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation, including but not limited to the following:
 - a. Replace belts and hoses as needed.
 - b. Replace air filters as needed.
 - c. Replace oil and oil filter annually.
 - d. Replace fuel filter annually.
 - e. Perform load bank test per NFPA 110 annually.
 - f. Clean diesel fuel system bi-annually.
3. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

PART 2. PRODUCTS

2.1. MANUFACTURERS

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

1. Caterpillar; Engine Div.
2. Kohler Power Systems; Rehlko (Basis of Design)
3. MTU Solutions.
4. Onan/Cummins Power Generation; Industrial Business Group.

2.2. ENGINE GENERATOR SET

- A. Factory-assembled engine-generator set.
- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- C. Capacities and Characteristics:
 1. Power Output Ratings: Nominal ratings as indicated on the Contract Drawings.
 2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. Generator Set Performance:
 1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
 2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
 3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
 4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
 5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
 6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
 7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
 8. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3. ENGINE

- A. Fuel: Fuel oil, Grade DF-2.

- B. Rated Engine Speed: 1800 rpm.
- C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).
- D. Lubrication System: The following items are mounted on engine or skid:
 - 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 - 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 - 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- E. Engine Fuel System:
 - 1. Fuel oil, Grade DF-2
 - a. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 - b. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for heater capacity.
- G. Governor: Adjustable isochronous, with speed sensing.
- H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
 - 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anti-corrosion additives as recommended by engine manufacturer.
 - 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 - 3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 - 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 - 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- I. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine

backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
- J. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- K. Starting System: 12 or 24-V electric, with negative ground.
1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 3. Cranking Cycle: As required by NFPA 110 for system level specified.
 4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.
 5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
 6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
 7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
 8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
 - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
 - e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - f. Enclosure and Mounting: NEMA 250, Type 4X, wall-mounted cabinet.

2.4. FUEL OIL STORAGE

- A. Comply with NFPA 30.
- B. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:
 - 1. Tank level indicator.
 - 2. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of operation as indicated on the Contract Drawings at 100 percent of rated power output of engine-generator system without being refilled.
 - 3. Vandal-resistant fill cap.
 - 4. Emergency Vent: Vent shall be designed for use on above-ground fuel storage tanks, in accordance with applicable UL and NFPA Standards, to help prevent tanks from becoming over-pressurized or rupturing if exposed to fire. Vents shall be equipped with factory-installed mesh screens.
 - 5. Containment Provisions: Comply with requirements of authorities having jurisdiction.
 - 6. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
 - 7. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
 - 8. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.
 - 9. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in tank to operate a separate motor device that disconnects pump motor. Sensor shall signal solenoid valve located in fuel suction line to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine-generator set.

2.5. CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch shall also shut down generator set.
- B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch shall also shut down generator set.
- C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gauges shall be grouped in a common control and monitoring panel mounted

on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

- D. Indicating and Protective Devices and Controls: As required by NFPA 110 for system level specified, and the following:
1. AC voltmeter.
 2. AC ammeter.
 3. AC frequency meter.
 4. DC voltmeter (alternator battery charging).
 5. Engine-coolant temperature gage.
 6. Engine lubricating-oil pressure gage.
 7. Running-time meter.
 8. Ammeter-voltmeter, phase-selector switch(es).
 9. Generator-voltage adjusting rheostat.
 10. Start-stop switch.
 11. Overspeed shutdown device.
 12. Coolant high-temperature shutdown device.
 13. Coolant low-level shutdown device.
 14. Oil low-pressure shutdown device.
 15. Generator overload.
- E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- F. Common Remote Audible Alarm:
1. Comply with NFPA 110 requirements for system level specified. Include necessary contacts and terminals in control and monitoring panel.
 - a. Overcrank shutdown.
 - b. Coolant low-temperature alarm.
 - c. Control switch not in auto position.
 - d. Battery charger malfunction alarm.
 - e. Battery low-voltage alarm.
 2. Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.
 - a. Engine high-temperature shutdown.
 - b. Lube-oil, low-pressure shutdown.
 - c. Overspeed shutdown.
 - d. Remote emergency-stop shutdown.
 - e. Engine high-temperature pre-alarm.
 - f. Lube-oil, low-pressure pre-alarm.
 - g. Fuel tank, low-fuel level.
 - h. Low coolant level.
- G. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm

conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

- H. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.6. ENGINE START MONITORING SYSTEM

- A. Description: Engine start monitoring system that monitors the integrity/operability of engine start circuits from automatic transfer switches, and automatically starts engine-generator(s) when faults occur, with the following features:
 - 1. System shall be capable of monitoring up to eight (8) automatic transfer switches, including fire pump controllers with automatic transfer switches provided under Division 21.
 - 2. Modules shall utilize standard engine control wiring.
 - 3. Generator module shall provide two (2) Form “C” contacts, one (1) for engine start and one (1) for alarming.
 - 4. Generator module shall be equipped with status LEDs for each channel to determine system status (e.g. channel disabled, wiring fault, engine start inactive, engine start active).
 - 5. Transfer switch modules shall be compatible with and wire into any contact-based engine start signal.
 - 6. System shall provide visual and audible notification of circuit faults at the generator and remote annunciator(s).
- B. Provide ATS Engine Start Module 5101-ATS as manufactured by ASCO, or approved equal, at each automatic transfer switch including fire pump controllers with automatic transfer switches.
- C. Provide Generator Engine Start Module 5101-GEN as manufactured by ASCO, or approved equal by listed manufacturer, at each engine-generator.

2.7. GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:
 - 1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator set malfunction alarms.
 - 2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
 - 3. As overcurrent heating effect on the generator approaches the thermal damage

- point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
- 4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.
- B. Generator Circuit Breakers: Molded-case, electronic-trip type; 80 percent rated; complying with NEMA AB 1 and UL 489.
 - 1. Tripping Characteristic: Designed specifically for generator protection.
 - 2. Trip Rating: As indicated on the Contract Drawings.
 - 3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 - 4. Mounting: Adjacent to or integrated with control and monitoring panel.
- C. Ground-Fault Indication: Comply with NFPA 70, "Emergency Systems" requirements for signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.8. GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Enclosure: Drip-proof.
- G. Instrument Transformers: Mounted within generator enclosure.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Sub-transient Reactance: 12 percent, maximum.

2.9. OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, weatherproof aluminum housing, wind resistant up to 100 mph (160 km/h). Instruments and control shall be mounted within enclosure.
1. Enclosure shall have a pitched roof to prevent standing water.
 2. Lockable latching, hinged access panels/doors on each side and end of the enclosure shall be provided for ease of inspection, maintenance, repair, etc. Routine inspection points for fluids shall be easily accessible by means of lockable latching, hinged door/panel. Minimum of two (2) doors per side. Lockable latches shall be keyed alike.
 3. Lockable latching, hinged access panels/doors shall be secured in the open position with hardware integral to the enclosure.
 4. Access panels shall be removable by one person without tools.
 5. Stainless steel hardware shall be used to provide corrosion protection for all hinges, latches, screws, etc.
 6. External drains standards for fluids requiring routine replacement. External drains shall be capable of accepting NPT plug or other means to prevent accidental leaks or spills. Valves internal to the enclosure shall provide means of flow controls.
 7. Enclosure shall achieve a Level 2 sound attenuation.
- B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
- C. Basic Electrical Package: Pre-wired AC power distribution of all factory-installed features including block heater, two (2) GFCI protected internal 120-volt service receptacles, internal lighting, and commercial grade wall switch.
1. Load center powered by building source power with the following features:
 - a. 208Y/120V, three-phase, four-wire with 100-ampere main lugs only.
 - b. Surge protection device rated 120kA minimum.
 - c. Refer to Division 26 Section 262418, "Load Centers", for requirements.
 2. AC power distribution installed in accordance with NEC and all wiring within EMT conduit.
 3. DC Light Package: Prewired internal DC light package with four (4) vapor-proof LED fixtures within housing, arranged to illuminate controls and accessible interior. Battery drain limited with fuse protection and controlled through a 0-60 minute spring-wound, no-hold timer.
 4. Convenience Outlets: Factory wired, GFCI.
 5. Battery Charger: Mounting and pre-wiring of DC output and AC input. Battery charger located inside the enclosure and accessible through an access door.
 6. Block Heater: Prewired AC input, 208-240 volt, single phase.
- D. Convenience Outlets: Factory-wired, GFCI.

2.10. VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
- B. Restrained Spring Isolators: Freestanding, Steel, Open-Spring Isolators with seismic Restraint.
 - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to ¼-inch (6mm) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 - 2. Outside Spring Diameter: not less than 80 percent of compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed without deformation or failure.

2.11. FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.12. SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 - 1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

PART 3. EXECUTION

3.1. EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. INSTALLATION

- A. Comply with packaged engine generator manufacturers' written installation and alignment

instructions and with NFPA 110.

- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install packaged engine generator with elastomeric isolator pads on concrete equipment pad. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section "Hangers and Supports".
- D. Install packaged engine generator on cast-in-place concrete equipment base. Comply with requirements for equipment bases and foundations specified in Division 03 Section, "Cast-in-Place Concrete."
 - 1. Comply with requirements for seismic control devices.
 - 2. Comply with requirements for vibration isolation devices specified in this section.
- E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
- F. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions including in the listing or labeling of UL listed products.
- G. Provide branch circuits and motor starters, where required, from the emergency power supply system for the generator set auxiliaries.
- H. Provide and install emergency system conductors in a raceways system completely separate from other wiring. Control interconnection wiring shall be properly sized and run in a raceway separate from power cables.

3.3. CONNECTIONS

- A. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- B. Connect engine exhaust pipe to engine with flexible connector.
- C. Connect fuel piping to engines with a gate valve and union and flexible connector.
- D. Connect wiring according to Division 26 Section 260519, "Low-Voltage Electrical Power Conductors and Cables."
- E. Ground equipment according to Division 26 Section 260526, "Grounding and Bonding for Electrical Systems."
- F. Verify that neutral-ground bonds do not exist at any point within engine generators connected to three-pole transfer switches.
- G. Connect generator controller and/or remote annunciator to the fire alarm system as required to indicate the following signals:

1. Generator Running
 2. Generator Fault.
 3. Generator switch in non-automatic position.
- H. Connect generator controller and/or remote annunciator to the building automation system as required to indicate the following signals:
1. Generator Running
 2. Generator Fault.
 3. Generator switch in non-automatic position.
 4. Coordinate requirements with Division 23 Contractor.
- I. Connect generator engine start monitoring system to modules in transfer switches and to generator and remote annunciators per manufacturer's instructions to indicate faults in start wiring system. Refer to Division 26 Section 263600, "Transfer Switches", for additional information.
- 3.4. IDENTIFICATION
- A. Identify system components according to Division 26 Section 260553, "Identification for Electrical Systems."
- 3.5. FIELD QUALITY CONTROL
- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Tests and Inspections:
1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to the following:
 - a. "Cold Start" test.
 - b. Single-step full-load pick-up test.
 - c. Four hour full-load test.
 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.

- d. Verify that measurements are within manufacturer's specifications.
4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
7. Exhaust Emissions Test: Comply with applicable government test criteria.
8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
11. Provide full tank of fuel at completion of the on-site acceptance tests.
- C. Coordinate tests with tests for transfer switches and run them concurrently.
- D. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- H. Remove and replace malfunctioning units and reinspect and retest as specified above.
- I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- K. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to

portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6. DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to ad-just, operate, and maintain packaged engine generators. Refer to Division 01 Section, "Demonstration and Training."
 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
 2. Review data in maintenance manuals. Refer to Division 01 Section "Contract Closeout".
 3. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data".
 4. Schedule training with Owner, through Architect, with at least seven days' advance notice.
 5. Provide a minimum of four hours of instruction.
- B. Coordinate this training with that for transfer switches specified in Division 26 Section 263600, "Transfer Switches".

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.
- B. Related Sections include the following:
 - 1. Division 21 Section 211001, "Water Based Fire-Suppression System – Fire Pump" for automatic transfer switches for fire pumps.
 - 2. Division 26 Section 260510, "Elevator Equipment Wiring and Provisions", for interface(s) with elevators served by emergency power supply systems and transfer switches.
 - 3. Division 26 Section 263213, "Engine Generators", for engine generators serving transfer switches.

1.2. SUMMARY

- A. Section includes transfer switches rated 600 V and less, including the following:
 - 1. Automatic transfer switches.
 - 2. Nonautomatic transfer switches.
 - 3. Remote annunciation systems.

1.3. ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- 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, power sources, and load.

1.4. INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer and testing agency.
- B. Field quality-control reports as specified herein.

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, "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.
 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.
- C. Source Limitations: Obtain transfer switches and remote annunciator panels through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NEMA ICS 1.
- F. Comply with NFPA 70.
- G. Comply with NFPA 110, for transfer switches served by emergency generators.
- H. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.7. PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 1. Notify Architect, Construction Manager, and Owner no fewer than seven days in advance of proposed interruption of electrical services.
 2. Do not proceed with interruption of electrical service without Architect's, Construction Manager's, and Owner's written permission.
- B. Environmental Conditions: Transfer Switches shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 1. Ambient Temperature: Minus 15 to plus 40 deg C.
 2. Relative Humidity: 0 to 95 percent.

3. Altitude: Sea level to 1000 feet (300 m).

1.8. COORDINATION

- A. Coordinate size and location of concrete bases for pad-mounted and floor-mounted transfer switches. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

1.9. WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of transfer switches and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.10. MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 60 months' full maintenance by skilled employees of manufacturer's designated service organization.

1. Provide quarterly multi-point operational inspection including the following at a minimum:
 - a. Visually inspect all transfer switches.
 - b. Transfer load to emergency and verify proper operation.
 - c. Check time delay and overall operation.
 - d. Return system to automatic and advise of any needed repairs.
2. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation.
3. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Caterpillar; Engine Div.
 2. Emerson; ASCO Power Technologies, LP.
 3. ESL Power Systems.
 4. GE Zenith Controls.
 5. Kohler Power Systems; Rehlko (Basis of Design)
 6. Onan/Cummins Power Generation; Industrial Business Group.
 7. Russelectric, Inc.
 8. Spectrum Detroit Diesel.
 9. Trystar, Inc.

- B. Manual Transfer Switches for Portable Generators Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ESL Power Systems.
 - 2. Trystar, Inc.

2.2. TRANSFER-SWITCH PRODUCT GENERAL 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 with-stand 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 non-fused, 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. 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.

- K. 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, "Identification for Electrical Systems."
 - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
 - 4. Use NEMA 250, Type 12 enclosure if environment is generally dusty.
- L. Enclosures: General-purpose NEMA 250, complying with NEMA ICS 6 and UL 508, unless other-wise indicated.
 - 1. Type 1 for dry interior locations.
 - 2. Type 4X for damp or wet locations.

2.3. AUTOMATIC TRANSFER SWITCHES

- A. Comply with NFPA 110 requirements for emergency power supply system level specified in Division 26 Section 263213, "Engine Generators".
- B. Switching Arrangement: Double-throw type, incapable of pauses 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. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- E. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- F. Programmed Switch Neutral 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.
- G. Automatic Transfer-Switch Features:
 - 1. Undervoltage Sensing for Each Phase of Normal Source and Alternate Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be

- adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
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. Retransfer Delay Bypass: Momentary position to bypass transfer and re-transfer time delay
 6. Test Switch: Simulate normal-source failure.
 7. Switch-Position Pilot Lights: Indicate source to which load is connected.
 8. 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."
 9. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
 10. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
 11. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
 12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
 13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods 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. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is not available.

2.4. MANUAL TRANSFER SWITCHES FOR PORTABLE GENERATORS

- A. Operation: Manual transfer switch(es) shall consist of two (2) mechanically-interlocked molded case circuit breakers with externally operated handles marked “Primary” and “Alternate”. Cam-style male connectors shall be provided for connecting portable generator cables. Power distribution block and grounding terminals shall be also be provided within a pad-lockable enclosure.
- B. The main access shall be through an interlocked, hinged door that extends the full height of the enclosure. Access for portable generator cables with female cam-style plugs shall be via drawn flange cable entry opening(s) in the bottom of the enclosure for wall mount units, or hinged lower door for pad mount units. A hinged flap door shall be provided to cover the cable openings when cables are not connected. The hinged flap door shall allow cable entry only after the main access door has been opened.
- C. Manual transfer switch enclosure shall be NEMA Type 3R, constructed of continuous seam-welded, powder coated gavanneal steel. Enclosure shall be powder coated after fabrication; color shall be selected by Architect or Owner.
- D. Cam-style male connectors (inlets) shall be UL Listed single-pole separable type and rated 400 amps at 600VAC. Cam-style male connectors shall be color coded. Cam-style male connectors shall be provided for each phase and for ground, and shall also be provided for neutral if required. Each of the phase cam-style male connectors within the enclosure shall be factory-wired to a molded case circuit breaker. The ground cam-style male connectors shall be bonded to the enclosure, and a ground lug shall be provided for connection of the facility ground conductor. The neutral cam-style male connectors, if required, shall be factory wired to a power distribution block. None of the cam-style male connectors shall be accessible unless both molded case circuit breakers are in the “OFF” position and the main access door is open.
- E. A power distribution block shall be provided for load-side field wiring. The power distribution block shall be factory wired to the molded case circuit breakers.
- F. Molded case circuit breakers shall be UL Listed and the short circuit interrupt rating shall be a minimum of 35kAIC at 480VAC. Trip rating of the molded case circuit breakers shall be as shown on the drawings. One molded case circuit breaker shall be fed from utility power; the other molded case circuit breaker shall be fed from the cam-style male connectors to supply power from a portable generator. Both molded case circuit breakers shall include UL Listed door-mounted operating mechanisms (with provisions for a locking device), preventing the opening of the main access door unless both breakers are in the “OFF” position. Both molded case circuit breakers shall be mounted behind a deadfront panel. The load-side of the molded case circuit breakers shall not be energizable unless the main access door is closed and one of the molded case circuit breakers is in the “ON” position. The (2) molded case circuit breakers shall be safety interlocked by mechanical means to ensure that only one breaker can be closed at any given time.
- G. Manual transfer switch shall be suitable for use as service equipment in the USA as defined by the NEC.
- H. Manual transfer switch shall include permanently affixed operation instructions.
- I. Accessories:

1. Remote Start Terminal Block
2. Heater/Thermostat/De-Humidistat
3. Receptacle – 20A, 120V GFCI Duplex
4. Receptacle – 30A, 120V Twist-Lock
5. Auxiliary Contacts – (2) N.O. / (2) N.C.

- J. Basis of Design – Manual transfer switches shall be StormSwitch as manufactured by ESL Power Systems, Inc. or equal as approved by the Engineer.

2.5. REMOTE ANNUNCIATOR SYSTEM

- A. Functional Description: Remote annunciator panel shall allow monitoring of common alarm, remote testing of automatic transfer switches, and monitoring of the normal/emergency source for each emergency and legally required power supply system transfer switch. Annunciation shall include the following:
1. Sources 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.
- C. Basis of Design: Provide RSA III with Four ATS Controls as manufactured by Kohler Power Systems, or approved equal by listed manufacturer.

2.6. 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. Wall-Mounted Transfer Switches: Anchor to wall by bolting.
1. Design each fastener and support to carry load indicated by manufacturer. See Division 26 Section 260529, “Hangers and Supports for Electrical Systems”.
- B. Floor-Mounted Transfer Switches: 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 other-wise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section 260500, "Common Work Results for Electrical".
- C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- D. Identify components according to Division 26 Section 260553, "Identification for Electrical Systems".
- 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 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."
- D. Connect transfer switch(es) to the fire alarm system as required to indicate the following signals:
 1. Switch in non-automatic position.
- E. Connect engine start monitoring modules in transfer switches to module in generator and to terminals in transfer switches per manufacturer's instructions.

3.3. FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 1. 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 connection, 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 microhms and values for 1 pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

D. 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 connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
4. Prior to energizing manual transfer switches for portable generators, the Contractor shall perform the following checks and tests as a minimum:
- a. Verify mounting and connections are complete and secure.
 - b. Verify internal components and wiring are secure.
 - c. Perform continuity check of all circuits.
 - d. Perform 1,000 VDC megger test on feeder, load and ground cables.
 - e. Verify deadfront is secure.

- f. With the manual transfer switch deadfront in place and the main access door closed and properly latched, actuate both Operator Mechanisms; verify only (1) breaker at a time can be turned to the “ON” position.
 - g. Confirm operation of the manual transfer switch ground receptacle by attaching a plug to the manual transfer switch ground receptacle and then verify that the plug is grounded to the facility ground.
 - h. Once utility power has been applied, confirm operation of manual transfer switch by following directions on main access door.
- 5. 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 and each phase of alternate source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- 6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a. Verify grounding connections and locations and ratings of sensors.
- E. Coordinate tests with tests of generator and run them concurrently.
- F. 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.
- G. Remove and replace malfunctioning units and retest as specified above.
- H. Prepare test and inspection reports.
- I. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for

device.

3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4. CLEANING

- A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean equipment internally, on completion of installation, according to manufacturer's written instructions.

3.5. 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, "Demonstration and Training."
 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
 2. Review data in maintenance manuals. Refer to Division 01 Section, "Contract Closeout".
 3. Review data in maintenance manuals. Refer to Division 01 Section, "Operation and Maintenance Data".
 4. Schedule training with Owner, through Architect, with at least seven days' advance notice.
 5. Provide a minimum of four hours of instruction.
- B. Coordinate this training with that for generator equipment specified in Division 26 Section 263213, "Engine Generators".

END OF SECTION

DIVISION 26 SECTION 26 41 13
LIGHTNING PROTECTION SYSTEM
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SECTION 26 41 13 - LIGHTNING PROTECTION 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.
- B. Related Sections include the following:
 - 1. Division 01 Section “Alternates” for description of work under this Section affected by Alternates.
 - 2. Division 26 Section 260500, “Common Work Results for Electrical”, for basic electrical installation requirements.
 - 3. Division 26 Section 260526, “Grounding and Bonding for Electrical Systems”, for grounding electrode and grounding connector requirements.
 - 4. Division 26 Section 260533, “Raceways and Boxes for Electrical Systems” for non-metallic conduits for concealing lightning protection system conductors.
 - 5. Division 26, Section 262413, “Switchboards”, for requirements related to internally-mounted surge protection devices (SPDs) in switchboards.
 - 6. Division 26, Section 262416, “Panelboards”, for requirements related to internally-mounted surge protection devices (SPDs) in panelboards.
 - 7. Division 26, Section 264313, “Surge Protection for Low-Voltage Electrical Power Circuits”, for requirements related to externally-mounted surge protection devices (SPDs).

1.2. SUMMARY

- A. This section includes lightning protection systems for buildings and associated structures and includes requirements for lightning protection system components complying with UL96, UL96A, and NFPA 780.
- B. Contractor shall provide additional components and labor in order to meet all requirements of a UL Master Labeled Lightning Protection System.

1.3. SYSTEM DESCRIPTION

- A. Protect entire building, including roof projections, chimneys, and roof-mounted equipment.
 - 1. Building Construction: Steel building less than 75 feet (23 m) in height.
 - 2. Building Occupancy: Commercial.
- B. Protect all ancillary buildings and structures on the main building property/campus, including, but not limited to, the following:
 - 1. Metal Storage Building(s)
- C. Provide a complete UL Master Labeled Lightning Protection System.

- D. Provide a complete all-inclusive Lightning Protection System Design layout and installation for a complete UL Master Labeled Lightning Protection System.
- E. Design Requirements: Lightning Protection Conductor System consisting of air terminals on roofs, roof-mounted mechanical equipment, parapets, bonding of structure and other metal objects, grounding electrodes, and interconnecting conductors.
- F. Provide an all-inclusive Lightning Protection System. The Contract Drawings and Specifications do not necessarily limit the extent of the system that is required to meet the requirements and the intent of the Engineer and the Contract Documents for a complete system.

1.4. SUBMITTALS

- A. General: Submit the following according to Conditions of Contract and Division 01 Specification Sections.
- B. Product data for each component: Include data for roof adhesive when used. Submit accurate pictorial views of decorative air terminal components. Provide dimensions and materials of each components and include indication of listing in accordance with UL 96.
- C. Provide scaled shop drawings detailing lightning protection system including, but not limited to, air terminal locations, grounding electrodes, conductor sizes and routing, bonding connections to structures, and connections and grounding. Include connection and termination details. The shop drawings shall be Master Labeled stamped. Submit a roof plan and a ground floor plan with all equipment properly dimensioned.
- 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 Architects and Owners, and other information specified.
- E. Field inspection reports indicating compliance with specified requirements.
- F. Project Record Documents - Accurately record the following: Actual locations of air terminals, grounding electrodes, bonding connections, and routing of system conductors in project record documents.
- G. Submit a UL compliance certificate indicating compliance with all requirements.

1.5. QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced and LPI-Certified Master Installer to install the Lightning Protection System. The installation shall be under the direct supervision of an LPI-Certified Master Installer.
- B. Designer Qualifications: Engage an LPI-Certified Designer to design and lay out the Lightning Protection System.
- C. Inspector Qualifications: Engage an LPI-Certified Inspector to perform periodic inspections during installation of the Lightning Protection System.

- D. Manufacturers Qualifications: Provide products by firms listed and approved by Underwriters Laboratories, Inc., having had not less than five (5) years' experience in this specialty work under UL procedures.
- E. Listing and Labeling: Provide products specified in this Section that are listed and labeled by an organization concerned with product evaluations, and that can determine compliance with appropriate standards for the current production of listed items.
 - 1. Listing and Labeling Agency Qualifications; A Nationally Recognized Testing Laboratory (NRTL) as defined in OSHA Regulation 1910.7.
- F. Conform to NFPA 780, Lightning Protection Code.
- G. Conform to UL 96, Standard for Lightning Protection Components.
- H. Conform to UL 96A, Installation Requirements for Lightning Protection Systems and provide UL Master Label.
- I. Conform to LPI-175, Lightning Protection Installation Standard and provide LPI-certified system.
- J. Conform to NFPA 70, National Electrical Code.
- K. Conform to the most stringent requirements when more than one standard is specified for products or installation.

1.6. WORKMANSHIP

- A. Guarantee all materials and workmanship furnished and installed under this section of the specifications two years from the date of final acceptance of work. The Contractor also agrees that he will, at his own expense, repair and/or replace all such defective materials or effective workmanship which become defective during the term of this guarantee.

1.7. SEQUENCING AND SCHEDULING

- A. Coordinate installation of lightning protection system with the installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection system, and building finishes.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturer's offering lightning protection components that may be incorporated in the Work include, but are not limited to, the following:
 - 1. A-C Lightning Security, Inc.
 - 2. Bonded Lightning Protection, Inc.
 - 3. Dillon Lightning Protection Systems, Inc.

4. East Coast Lightning Equipment, Inc.
5. Harger Lightning and Grounding; Harger, Inc.
6. Heary Brothers Lightning Protection.
7. Independent Protection Company, Inc.
8. Robbins Lightning Protection, Inc.
9. Thompson Lightning Protection.
10. Warren Lightning Rod Company.

2.2. LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. Lightning Protection System Products: Manufactured to NFPA 780, LPI-176, Lightning Protection System Material and Components Standard, and UL 96, Lightning Protection Components.
- B. Copper materials shall not be installed on or in contact with aluminum roofing, aluminum siding, or other aluminum surface. Aluminum materials shall not be installed on or in contact with copper surfaces.
- C. Air Terminals for Roof Mounting: Units with bases especially designed for the specified roof materials.
 1. Solid with blunt points, extending a minimum of 12 inches above the protected object.
 - a. Copper: 3/8 inch diameter
 - b. Aluminum: 1/2 inch diameter
 2. Air Terminal Bases: Cast bronze with bolt pressure cable connections and shall be securely mounted with stainless steel screws and bolts. Bases on modified bitumen roofs shall be secured with a proper adhesive.
- D. Class I Conductors, Minimum Requirements:
 1. Main Conductors:
 - a. Copper
 - i. 57,400 circular mils
 - ii. 187 lbs. / 1,000 Linear Feet (LF)
 - iii. 17 AWG conductors
 - b. Aluminum
 - i. 98,600 circular mils
 - ii. 95 lbs/1,000 Linear Feet (LF)
 - iii. 14 AWG conductors
 2. Secondary Conductors:
 - a. Copper
 - i. 26,240 circular mils
 - ii. 17 AWG conductors
 - b. Aluminum
 - i. 41,100 circular mils

ii. 14 AWG conductors

- E. Counterpoise: Minimum 1/0 AWG stranded copper, tinned for corrosion protection.
- F. Ground Rods: Copper clad steel (10 mil finish) with a minimum of 7 percent of the rod weight in the copper cladding.
 - 1. Diameter: 3/4 inch (19 mm).
 - 2. Length: 10 feet (3 m).
- G. Ground Plate: Solid copper, not less than 1/16th inch (2mm) thick.
- H. Connectors and Splices: Exothermic, conforming to UL 96.
- I. Ground Test Well: For accessible connection for testing. Ground test well shall be heavy duty 12-inch length (minimum) with cast iron lid and frame.
- J. Roof Penetrations: Through-roof assemblies with solid bars and appropriate roof flashings.
- K. Miscellaneous Components: Provide other components required for a complete lightning protection system such as bonding plates, terminal supports, clips, anchors, fasteners, bolts, nuts, screws, etc. All components shall conform to UL 96 for applicable classes.
 - 1. Bonding plates shall not be less than 8 square inches of surface contact secured in place with stainless steel bolts.
- L. Conduit: Provide 1-inch Type 40 PVC conduit for all down conductors. Refer to Division 26 Section 260533, "Raceway and Boxes for Electrical Systems" for product requirements.
- M. Waterproof Penetrations: The Contractor shall provide all waterproofing for the through-roof conduits, connectors, and other penetrations.

PART 3. EXECUTION

3.1. EXAMINATION

- A. Verification of Conditions: Verify that field measurements, surfaces, substrates and conditions are as required, and ready to receive work.
- B. Examine surfaces and conditions, with Installer present, for compliance with installation tolerances and other conditions affecting performance of the lightning protection system. Do not proceed with installation until unsatisfactory conditions have been corrected.
- C. By beginning work, conditions are accepted with the responsibility for correcting unsuitable conditions encountered at no additional cost to the Owner.
- D. Lightning Protection System shall be provided with UL Master Label Certificate. Turn UL Master Label Certificate over to Owner upon system approval, and include one (1) copy of the same in the Operation and Maintenance Manual(s).

3.2. INSTALLATION

- A. Install lightning protection systems according to manufacturer's written instructions.
- B. Install components according to LPI-175, UL 96A, and NFPA 78.
- C. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops. Run conductors in nonmetallic raceway, Schedule 40, minimum.
- D. Conceal interior system conductors and down conductors.
- E. Support conductors every three (3) feet.
- F. Notify Engineer at least 48 hours before concealing lightning protection system components.
- G. In all areas where cables come in direct contact with aluminum material, aluminum cables must be used to prevent electrolytic corrosion of the dissimilar metals.
- H. Aluminum materials shall not be used within 18-inches of the point where the lightning protection system conductor comes into contact with the earth.
- I. If the building has structural steel columns, the structural steel columns may be used as the down-conductors.
- J. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.
- K. Air Terminals on Specified roofing: Use adhesive recommended by manufacturer of air terminals and approved by manufacturer of roofing material. Comply with adhesive manufacturer's installation instructions. Maximum spacing of 25 feet.
- L. Bond extremities of vertical metal bodies exceeding 60 feet (18 m) in length to the Lightning Protection System.
- M. Bond ground terminals with counterpoise conductor located below grade.
- N. Bond grounded media on building within 12 feet (4 m) of ground with counterpoise conductor located as indicated.
- O. Bond grounded media on building within 1 foot (0.3 m) of roof with counterpoise conductor.
- P. Bond grounded media on building within 12 feet (4 m) of roof with interconnecting loop at eave level or above.
- Q. Bond lightning protection system to grounded media on building at every 60 feet (18 m) with intermediate-level interconnection loop conductors.
- R. Install the conductors as inconspicuously as practical and with the proper bends. Install

conductors avoiding radius bends of less than 8 inches.

- S. Install the vertical conductors within the concealed cavity of exterior walls. Route the conductors to the exterior at elevations below the finished grade and make the ground connections to the earth outside of the building or stack perimeter.
- T. Where shown, use the structural steel framework or reinforcing steel as the main conductor: Weld or bond the non-electrically-continuous sections together and make them electrically-continuous.
- U. Protect copper conductors with stiff copper or brass tubing, which enclose the conductors from the top to the bottom of the tubing, between 300 mm (one foot) below and 2100 mm (seven feet) above the finished grade.
- V. Sheath copper conductors, which pass over cast stone, cut stone, architectural concrete, and masonry surfaces with not less than a 2 mm (1/16-inch) thickness of lead to prevent staining of the exterior finish surfaces.

3.3. AIR TERMINAL INSTALLATION

- A. Install per UL and NFPA requirements:
 - 1. Rigidly connect to structure.
 - 2. Make electrically continuous with roof conductors by means of pressure connectors or crimped joints.
 - 3. At ends of structures, set 24-inches from end of ridge or edges and corner of roof.
 - 4. Maximum spacing of 25 feet.
 - 5. Prevent overturning by means of tripod or braces.
 - 6. Uniformly space air terminals about the rim of the stack, not more than 24 inches from the corners or more than 8'-0-inches apart.
 - 7. Air terminals on standing seam metal roof systems shall be secured with aluminum clamps designed for standing seam metal roofing systems.

3.4. ROOF CONDUCTORS

- A. Install per UL and NFPA requirements:
 - 1. Connect directly to roof or ridge at 48-inch intervals.
 - 2. Prevent sharp bends or turns.
 - 3. Minimum bend radius of 8 inches.
 - 4. Provide a downward or horizontal course.
 - 5. All connections shall be electrically continuous.
 - 6. Follow contours of flat roofs, ridges, parapets and edges.

3.5. DOWN CONDUCTORS

- A. Installation:
 - 1. Do not pass through non-conducting parts of structure.
 - 2. Interconnect secondary conductors with grounded parts within the building.

- B. Down Lead Conductors Run in Raceways:
 - 1. All down lead conductors shall be run in 1-inch Type 40 PVC conduit.
 - 2. All raceways shall be concealed wherever possible.
 - 3. Bends shall be kept to a minimum and where used shall have an angle not to exceed 90 degrees.
 - 4. Openings shall be free and clear.
 - 5. Contractor shall provide conduits at various locations in the outer walls as required.
- C. Provide a minimum of two down conductors located as widely separated as possible, at diagonally opposite corners.
- D. Down lead cables shall not be brought directly through the roof. Through-roof assemblies with solid rods shall be used for this purpose.

3.6. INTERCONNECTION OF METAL PARTS

- A. Metal ventilators shall be rigidly connected to the roof conductor at three places on the ventilator.
- B. Metal bodies of conductance shall be protected if not within the zone of protection of the air terminals. All metal bodies having equal to, or greater than, 400 square inches shall be bonded to the lightning protection system using main size conductors and a bonding plate with not less than 3 square inches. Provisions shall be made to guard against corrosion due to joining of dissimilar metals. Provide air terminals on metals that are less than 3/16th-inch thick, which are not in the cone of protection on roof areas, such as ventilators, air conditioning units, etc., all as required by the stated Code.
- C. All major rooftop mechanical equipment and isolated metal bodies within 6 feet of system conductors shall be bonded to lightning protection system's main roof conductor with secondary conductors and appropriate bonding devices. Do not penetrate airside housings for anchoring. Seal air and water tight all connections at mechanical equipment.
- D. Interconnect conductive and inductive metals as required by the UL 96A Code.

3.7. GROUND CONNECTIONS

- A. Use exothermic welding type connections which form solid metal joints in the main vertical and horizontal conductors, and for connections that are not exposed in the finish work.
- B. Provide ground connection for each down conductor.
- C. Metal water pipes and other large underground metallic objects shall be bonded together with all grounding mediums.
- D. Ground connections shall be protected from mechanical injury.
- E. In making ground connections, utilize permanently moist areas as applicable.
- F. For the conductors located outside of the building, install the conductors not less than 2 feet (600 mm) below the finished grade.

- G. Make connections of dissimilar metal with bi-metallic type fittings to prevent electrolytic action.
- H. For structural steel buildings, connect the steel framework of the buildings to the main water pipe near the water system entrance to the building.
- I. Connect exterior metal surfaces, located within 900 mm (three feet) of the lightning protection system conductors, to the lightning protection system conductors to prevent flashovers.
- J. Do not pierce the structural steel in any manner. Connections to the structural steel shall conform to the UL Publication No. 96A.
- K. Install ground connections to earth at not more than 1800 mm (60 foot) intervals around the perimeter of the building.
- L. Weld or braze bonding plates, not less than 200 mm (eight inches) square, to cleaned sections of the steel and connect the conductors to the plates.
- M. Connections to Lightning Protection System: Bond grounding conductors, including grounding-conductor conduits, to lightning protection down conductors or lightning protection grounding conductors in compliance with NFPA 780.
- N. Common Ground Bonding with Lightning Protection System: Bond electric power system ground directly to lightning protection system grounding conductor at closest point to electric service grounding electrode. Use bonding conductor sized same as system grounding conductor and install in conduit.

3.8. GROUNDING ELECTRODES

- A. Provide for each down conductor.
- B. Drive into earth minimum of 10 feet. Ground rods shall be not less than 2 feet, nor more than 10 feet from the structure.
- C. Ground rods shall be installed such that the top is not less than 2 feet below finished grade.
- D. Ground rod resistance shall not exceed 10 ohms. The resistance of the entire grounding system shall not exceed 5 ohms.
- E. Provide test wells installed flush with the finished grade.
- F. Counterpoise shall be No. 1/0 AWG tinned copper cable and shall be laid around the perimeter of the structure in a trench.

3.9. CORROSION PROTECTION

- A. Use no combination of materials to form an electrolytic couple that will accelerate corrosion in the presence of moisture, unless moisture is permanently excluded from the junction of such materials.

- B. Use conductors with suitable protective coatings where conditions would cause deterioration or corrosion of conductors.

3.10. FIELD QUALITY CONTROL

- A. Periodic Inspection: Provide the services of a qualified inspector to perform periodic inspection according to LPI-177, Inspection Guide for LPI Certified Systems.
- B. UL Inspection: Provide the services of Underwriters Laboratories, Inc. to perform inspections. Make revisions as required to obtain Master Label Certificate.
- C. Certification: Two weeks prior to final inspection, deliver to the Owner four copies of the Certification that the installed lightning protection system has been inspected by a UL representative and has been approved by UL without variation.
- D. Prior to commencement of any work, the Contractor shall obtain and deliver to the Owner the application and inspection forms necessary to file application for the LPI Certified System Certificates. As applicable, these forms include: Stage 1 - Grounding Inspection Report; Stage 2 - Concealed Components Inspection Report; and Stage 3 - Final Inspection Report.
- E. The Contractor shall perform required inspections at the appropriate times and upon completion of the job shall forward the above Inspection Report forms to the Lightning Protection Institute to obtain the LPI Certified System Certificate.
- F. Verify the electrical continuity by measuring the ground resistance to earth at the ground level, at the top of the building or stack, and at intermediate points with a sensitive ohmmeter. Compare the resistance readings. Ground resistance shall not exceed 5 ohms. Submit test results.

END OF SECTION

DIVISION 26 SECTION 26 51 00
INTERIOR LIGHTING
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SECTION 26 51 00 - INTERIOR 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.
- B. Related Sections include the following:
 - 1. Division 26 Section 260943, “Network Lighting Controls” for network lighting control systems controlling interior lighting fixtures.
 - 2. Division 26 Section 262726, “Wiring Devices” for wallbox toggle switches, wallbox occupancy sensor switches, and wallbox timer switches controlling interior lighting fixtures.

1.2. SUMMARY

- A. This Section includes interior lighting fixtures, LED light sources, electronic LED drivers, emergency lighting units, and accessories.
- B. Provide a lighting fixture for each fixture shown on the Drawings as described in this Specification, of the design and quality indicated herein. Provide fixtures complete, including light sources of the type, lumen output, and CCT indicated.
- C. All materials, accessories, and any other equipment necessary for the complete and proper installation of all lighting fixtures included in this contract shall be furnished by the Contractor.
- D. Conformance: Fixtures shall be manufactured in strict accordance with the Contract Drawings and Specifications.
- E. Specifications and scale Drawings are intended to convey the salient features, function and character of the fixtures only, and do not undertake to illustrate or set forth every item or detail necessary for the work.
- F. Minor details, not usually indicated on the Drawings nor specified, but that are necessary for the proper execution and completion of the fixtures, shall be included, the same as if they were herein specified or indicated on the Drawings.
- G. Omissions: The Owner shall not be held responsible for the omission or absence of any detail, construction feature, etc., which may be required in the production of the fixtures. The responsibility of accurately fabricating the fixtures to the fulfillment of this Specification rests with the Contractor.

1.3. DEFINITIONS

- A. ALCR: Automatic Load Control Relay.
- B. CCT: Correlated Color Temperature.

- C. CRI: Color Rendering Index.
- D. DLC: Design Lights Consortium.
- E. ELCD: Emergency Lighting Control Device.
- F. GTD: Generator Transfer Device.
- G. IDA: International Dark-Sky Association.
- H. IES: Illuminating Engineering Society.
- I. LED: Light Emitting Diode.
- J. LPW: Lumens per Watt.
- K. Luminaire (Light Fixture): A complete lighting device consisting of light source(s) and driver(s), when applicable, together with parts designed to distribute light, to position and protect light sources, and to connect light sources to power supply.

1.4. SUBMITTALS

- A. Product Data: Submit fixture shop drawings in booklet form with separate sheet for each type of lighting fixture indicated, arranged in order of fixture designation. Include data on features, accessories, and the following:
 - 1. Dimensions of fixtures.
 - 2. Certified results of independent laboratory test for fixtures and lamps for electrical ratings and photometric data. Test data shall include manufacturer and model number for fixture being submitted.
 - 3. Light Sources.
 - 4. Electronic LED Drivers.
- B. Shop Drawings: Show details of nonstandard or custom fixtures. Indicate dimensions, weights, method of field assembly, components, features, and accessories.
 - 1. Wiring Diagrams: Detail wiring for fixtures and differentiate between manufacturer-installed and field-installed wiring.
- C. Coordination Drawings: Reflected ceiling plans and sections drawn to scale and coordinating fixture installation with ceiling grid, ceiling-mounted items and other components in the vicinity. Include work of all trades that is to be installed near lighting equipment.
- D. Samples for Verification: For lighting fixtures requested for sample submission by the Owner and/or Architect/Engineer. Refer to paragraph “Samples”, in this Section, for additional information.
 - 1. Lamps: Specified units installed.
 - 2. Ballast: 120-V model of specified ballast type.
 - 3. Accessories: Cord and plug.

- E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- F. Record Documents: Accurately record actual location of each luminaire with the associated switching/control arrangement.
- G. Maintenance Data: For lighting fixtures to include in maintenance manuals specified in Division 01. Include technical data sheets and parts ordering information. Include testing and maintenance requirements and instructions for emergency lighting equipment.
- H. Lighting Calculations: Submit point-by-point lighting calculations for spaces where fixtures being submitted are not listed on the Interior Lighting Fixture Schedule on the Contract Drawings. All calculations shall strictly conform to IES Standards.

1.5. SAMPLES

- A. After shop drawing review and prior to release for manufacturing, the Contractor shall furnish one sample of each fixture in this Specification for which sample requirement is noted.
- B. Shipping: The samples shall be complete with specified light sources and compatible driver(s), ready for hanging, energizing, and examining, and shall be shipped, prepaid by the Contractor, to the Architect/Engineer, or as otherwise advised.
- C. Two weeks from the date received shall be allowed for thorough examination of the samples by the Architect/Engineer.
- D. Return: Samples are returnable, the Contractor shall arrange for return, prepaid shipping and pickup of each sample submitted.
- E. Samples must be actual working units of materials to be supplied.
- F. Samples shall be submitted by the Contractor for each substituted lighting fixture as requested for review by the Owner and/or Architect/Engineer.

1.6. QUALITY ASSURANCE

- A. Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction. Provide only UL listed and labeled fixtures with UL listed wiring. Wiring shall be suitable for the fixture temperature listing.
- B. Comply with NFPA 70.
- C. FM Compliance: Fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM.
- D. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.
- E. Mockups: Provide lighting fixtures for room or module mockups where required by the Architect. Install fixtures for mockups with power and control connections.

1. Obtain Architect's approval of fixtures for mockups before starting installations.
 2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 3. Remove mockups when directed. Fixtures may be reinstalled in the Work with approval of Architect.
 4. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- F. UL Listing: All fixtures shall be manufactured in strict accordance with the appropriate and current requirements of the Underwriters' Laboratories, Inc. (Standards for Safety), and others as they may be applicable. A UL listing shall be provided for each fixture type and the appropriate label or labels shall be affixed to each fixture in a position concealing it from normal view.
- G. Installer: All Installers shall have not less than five (5) years' experience in the installation of lighting fixtures of the type and quality shown.
- H. Materials, equipment and appurtenances, as well as workmanship provided under this Section, shall conform to the highest commercial standard as specified and as indicated on the drawings.
- I. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Articles 220, 410, and 510 as applicable to installation, and construction of interior building lighting fixtures.
- J. NEMA Compliance: Comply with applicable requirements of NEMA Standards Publication Numbers LE1 and LE2 pertaining to lighting equipment and LE4 pertaining to recessed luminaires.
- K. IES Compliance: Comply with IES RP-1 pertaining to office lighting practices and RP-15, regarding selection of illuminance values for interior office building.
- L. UL Compliance: Comply with UL Standards, including UL 486A and B, pertaining to interior lighting fixtures. Provide interior lighting fixtures and components which are UL-listed and labeled and comply with the following UL Standards:
1. UL 1598 – Luminaires (Tri-national standard)
 2. UL 8750 – Light Emitting Diode (LED) Equipment for Use in Lighting Products
 3. UL 8753/ULC-S8753 – Standard for Field-Replaceable Light Emitting Diode (LED) Light Engines
 4. UL 8754/ULC-S8754 – Holders, Bases, and Connectors for Solid-State (LED) Light Engines and Arrays.
 5. UL 924 – Emergency Lighting and Power Equipment
- M. NECA/IESNA Compliance: Comply with NECA/IESNA 500 Standard, Installing Indoor Commercial Lighting Systems (ANSI).

1.7. COORDINATION

- A. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction. Provide plaster frames, hangers, trim

rings, and fittings, as required for each type of ceiling construction.

- B. The Contractor shall coordinate switch and lighting control devices with door swings and other architectural features.
- C. The Contractor shall be responsible for providing the required quantity of ballasts to provide the control and operations of the lighting fixtures as indicated by the lighting controls on the Drawings. For example, where two switches are indicated to serve fixtures, then two ballasts per fixture shall be provided.

1.8. 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 for Batteries: Written warranty, executed by manufacturer agreeing to replace rechargeable batteries that fail in materials or workmanship within specified warranty period.
 - 1. Special Warranty Period for Batteries: Manufacturer's standard, but not less than 5 years from date of Substantial Completion.
- C. Special Warranties for Electronic Drivers: Written warranty, executed by manufacturer agreeing to replace ballasts and drivers that fail in materials or workmanship within specified warranty period.
 - 1. Special Warranty for Electronic Drivers: Five (5) years from date of manufacture, but not less than four years from date of substantial completion.

1.9. EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. LED Circuit Boards: 1 for every 50 of each type and rating installed. Furnish at least one of each type.
 - 2. Plastic Diffusers and Lenses: 1 for every 50 of each type and rating installed. Furnish at least one of each type.
 - 3. Electronic LED Drivers: 1 for every 20 of each type and rating installed. Furnish at least one of each type.
 - 4. Emergency ballasts and/or automatic load control relays: 1 for every 20 of each type and rating installed. Furnish at least one of each type.
 - 5. Globes and Guards: 1 for every 50 of each type and rating installed. Furnish at least one of each type.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Products: Subject to compliance with requirements, products that may be incorporated into the Work include, the products indicated in this Specification.
- B. Data listed and model number shown, in this Specification for each fixture type indicate minimum requirements and no exceptions will be made.

2.2. FIXTURES AND FIXTURE COMPONENTS, GENERAL

- A. Metal Parts: Free from burrs, sharp corners, and edges.
- B. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.
- D. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
 - 4. Laminated Silver Metallized Film: 90 percent.
- E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.
 - 1. Plastic for lenses and diffusers shall be formed of colorless 100% virgin acrylic as manufactured by Rhom & Haas, Dupont, or as acceptable. The quality of the raw material must equal or exceed IES, SPI and NEMA Specifications by at least 100%--which, as a minimum standard, shall not exceed a yellowness factor of 3 after 2,000 hours of exposure in the Fade-meter or as tested by an independent test laboratory. Acrylic plastic lenses and diffusers shall be properly cast, molded or extruded as specified, and shall remain free of any dimensional instability, discoloration, embrittlement, or loss of light transmittance for at least 15 years.
 - 2. Lens Thickness: 0.125 inch (3 mm) minimum, unless greater thickness is indicated.
 - 3. Glass used for lenses, refractors, and diffusers in lighting fixtures shall be tempered for high impact and heat resistance; the glass shall be crystal clear in quality with a transmittance of not less than 88%. For exterior fixtures, use tempered Borosilicate glass, Corning #7740, or as acceptable. For fixtures directly exposed to the elements and aimed above the horizontal with a radiant energy of 4.16 watts per square inch, or greater, use Vycor glass.
 - 4. Where optical lenses are used, they shall be free from spherical and chromatic aberrations and other imperfections which may hinder the functional performance of the lenses.

- 5. Mechanical: All lenses, louvers, or other light diffusing elements shall be removable, but positively held so that hinging or other normal motion will not cause them to drop out.
- 6. Cleaning: All lenses shall be turned over to the Owner clean and free of dust.
- F. Hardware: All hardware (e.g. screws, nuts, washers, latches, etc.) for fixtures located in damp/wet locations shall be stainless steel, unless otherwise indicated on the drawings.

2.3. FIXTURES

- A. Refer to “Interior Lighting Fixture Schedule” on the Contract Drawings.

2.4. FINISHES

- A. Painted Surfaces: Synthetic enamel, with acrylic, alkyd, epoxy, polyester, or polyurethane base, light stabilized, baked on at 350 degree Fahrenheit minimum, catalytically or photo-chemically polymerized after application. All painted surfaces shall be painted after fabrication.
- B. Ceiling opening frames shall either be manufactured of non-ferrous metal, or be suitably rust-proofed after fabrication.
- C. Selection: Unless otherwise noted, finishes shall be as selected by the Architect.
- D. Undercoat: Except for stainless steel, give ferrous metal surfaces a five-stage phosphate treatment or other acceptable base bonding treatment before final painting and after fabrication.
- E. Unpainted non-reflecting surfaces shall be satin finished and coated with a stoved clear lacquer to preserve the surface. Where aluminum surfaces are treated with an anodic process, the clear lacquer coating may be omitted.
- F. Unpainted Aluminum Surfaces: Finish interior aluminum trims with an anodized coating of not less than 7 mg per square inch, of a color and surface finish as selected by the Architect. Finish exterior aluminum trims with an anodized coating of not less than 35 mg per square inch or a color and surface finish as selected by the Architect.
- G. Porcelain Enamel Surfaces: Apply porcelain finishes smoothly. Finish shall be not less than 7.5 mils thick of non-yellowing, white, vitreous porcelain enamel with a reflectance of not less than 85%.
- H. Fixtures: Manufacturer's standard, unless otherwise indicated.
 - 1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects. All parts shall be painted after fabrication.
 - 2. Metallic Finish: Corrosion resistant.
- I. White finishes: Minimum of 85 percent reflectance.

2.5. FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section 260500, “Common Work Results for Electrical”, and 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 (12-mm) steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch (12-mm) steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.
- D. Rod Hangers: 3/16-inch- (5-mm-) minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
- F. Aircraft Cable Support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.
- G. Recessed fixtures shall be removable from below to allow access to outlet/junction boxes in ceiling spaces.
- H. Each fixture shall be supplied with necessary straps, supports, or hangers, or other miscellaneous materials and devices to install them in a satisfactory manner to conform to architectural treatment and finishes in area in which they are to be installed. Consult all Mechanical, Architectural and Structural Plans and related Contract Documents to be familiar with all necessary details for proper fixture placement. Failure to do so will not relieve the Contractor of responsibility of furnishing all necessary material, complete to perform function intended for indicated lighting system.

2.6. LED LIGHT SOURCES

- A. Manufacturers: Provide quality LED light sources by the manufacturers listed below, off brand/generic light sources shall not be acceptable.
 - 1. Cree
 - 2. Nichia
 - 3. Osram
 - 4. Philips
 - 5. Samsung
- B. Correlated color temperature (CCT): 4,000 Kelvin per ANSI C78.377, unless otherwise indicated on the Contract Drawings.
- C. Light sources shall have a maximum deviation of 3-step Macadam Ellipses.
- D. Color rendering index (CRI): 80 CRI minimum.
- E. L70 rating shall meet or exceed value indicated on the interior lighting fixture schedule.

- F. Light sources installed in outdoor environments shall be rated for low temperature applications (0°F, minimum).

2.7. LED ELECTRONIC DRIVERS

- A. Manufacturers: Provide quality LED electronic drivers by the manufacturers listed below. Off-brand/generic electronic drivers shall not be acceptable.

1. Advance (Philips Lighting Electronics)
2. eldo LED
3. General Electric (GE) Lighting
4. Lutron Electronics, Inc.
5. Osram Sylvania
6. Samsung
7. Universal Lighting Technologies, Inc.

- B. General Requirements:

1. Suitable for operating type and quantity of LED sources indicated at full light output.
2. No PCBs.
3. Suitable for dry and damp locations.
4. Starting temperature: 0 degrees Celsius.
5. 50,000 hour (minimum) design life.
6. Class 2 output UL recognized to UL and CSA requirements.

- C. Electrical Requirements:

1. 0-10V dimming standard, 1% minimum unless otherwise noted on the Contract Drawings.
2. Power Factor: 90 percent (0.9) minimum.
3. Total Harmonic Distortion (THD): Less than 20 percent.
4. Sound Rating: A.
5. Short circuit and overload protection standard.
6. Inherent thermal protection standard.

- D. Listings:

1. ANSI/UL 8750
2. ANSI C62.41: Category A for transient protection.
3. ANSI C82.16
4. FCC Part 15: Non-consumer equipment EMC.
5. UL 1310: Standard for Class 2 Power Units.

- E. Warranty:

1. Minimum five-year warranty.

2.8. EMERGENCY BATTERY PACKS

- A. Unless otherwise indicated, features include the following:

1. Conform to UL 924 “Emergency Lighting and Power Equipment”
2. Conform to NFPA 101 and International Building Code (IBC) requirements.
3. Initial Light Output: Provide as indicated.
4. Illumination time: 90 minutes, minimum.
5. Battery: Long life, high temperature, maintenance-free Nickel-Cadmium battery with test switch.
6. Self-Testing Diagnostics: Provide as indicated.
7. Cold Weather Operation: Provide as indicated.
8. Warranty: Minimum 5 year full product warranty.
9. Manufacturers: Provide specification grade emergency battery ballasts by the Manufacturers listed below. Off-brand/generic ballasts shall NOT be acceptable.
 - a. Bodine
 - b. Iota
 - c. Power Sentry

2.9. AUTOMATIC LOAD CONTROL RELAYS

- A. Emergency transfer relays shall be double pole. Double throw with continuous duty rated coil in a NEMA 1 enclosure.
 1. Units for individual lighting fixtures shall have contacts rated minimum 2.8 Ampere, 120/277 volt dual voltage input and be U. L. 924 listed.
 2. All other units shall have contact rated minimum 20 amperes, 120/277 volt dual voltage input and all U. L. 924 listed.
- B. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work included but are not limited to the following:
 1. Bodine
 2. IOTA Engineering
 3. Nine 24, Inc.
 4. Side-lite

2.10. EXIT SIGNS

- A. General Requirements: Comply with UL 924, “Emergency Lighting and Power Equipment”, and the following:
 1. Sign Colors and Lettering Size: Comply with authorities having jurisdiction.
- B. Internally Lighted Signs: As follows:
 1. Lamps for AC Operation: Light-emitting diodes (LED), 25 + years rated lamp life.

2.11. PROTECTIVE WIRE GUARDS

- A. Provide protective wireguards over lighting fixtures subject to physical damage. All new lighting fixtures installed in the gymnasium, in mechanical and electrical rooms, and in areas subject to physical damage 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 Fixtures
 - 2. Exit Signs
 - 3. Emergency Lighting Units
 - 4. Other Devices as required by Owner
- C. Guards shall be fabricated from ¼-inch (9-gauge) cold-rolled steel rods, welded together with mounting tabs. Guards shall be finished with a powder-based epoxy to protect against corrosion. Finish color shall match the finishes for the area being installed.
- 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.

PART 3. EXECUTION

3.1. INSTALLATION

- A. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials. Install lamps in each fixture.
- B. Support for Fixtures independent of ceiling systems, ducts, and piping.
 - 1. Provide support system rods or wires for each fixture from structure above. Locate not more than 6 inches (150 mm) from fixture corners.
 - 2. Support Clips: Fasten to fixtures and to ceiling grid members at or near each fixture corner.
 - 3. Fixtures of Sizes Less Than Ceiling Grid: Arrange 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.
- C. Suspended 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. Continuous Rows: Suspend from cable installed according to fixture manufacturer's written instructions and details on Drawings. Provide alignment fittings as required for uniform, level installation of continuous rows of suspended fixtures.
- D. Fixture installations with fixtures supported only by insecure boxes will be rejected. It shall be the Contractor's responsibility to support all lighting fixtures adequately, providing

extra steel work for the support of fixtures if required. Any components necessary for mounting fixtures shall be provided by the Contractor. No plastic, composition or wood type anchors shall be used.

- E. Setting and Securing: Set units plumb, square, and level with ceiling and walls, and secure according to manufacturer's printed instructions and approved shop drawings.
- F. Support for Recessed and Semi-Recessed Fixtures:
 - 1. Installed units shall not be supported from ceiling support system.
 - 2. Provide positive attachment from fixtures to ceiling grid.
 - 3. Provide #12 gauge safety/tie wires to structure above as follows:
 - a. Fixtures less than ten (10) pounds: One (1) wire.
 - b. Fixtures more than ten (10) pounds and less than fifty (50) pounds: Two (2) wires at diagonally opposite corners.
 - c. Fixtures more than fifty (50) pounds or larger than 2'x4': Four (4) wires, one (1) at each corner.
 - d. Linear fixtures: Two (2) wires at each end of fixture, plus two (2) wires every eight (8) feet between.
 - 4. Fixtures of Sizes Less than Ceiling Grid: Center in the acoustical panel. Support fixtures independently with at least two 3/4-inch metal channels spanning and secured to the ceiling tees.
 - 5. Recessed fixtures shall be provided with the proper plaster frame or suitable adapter to receive the finished ceiling construction.
 - 6. Recessed lighting fixtures shall be suitable for the ceiling or wall material and construction in which they will be installed.
 - 7. Recessed mounted lighting fixtures shall be connected to a junction box with flexible conduit. Final connection to light fixture shall be with heat-resistant wire.
- G. Each lighting fixture shall be rigidly supported from the building construction and shall include suspension hangers, devices, and extra steel work for fixture support where required.
 - 1. Support all lighting fixtures adequately. Special supports shall be installed as required.
 - 2. Luminaires shall be furnished with all necessary stems, plaster frames, hangers, for the safe support of the fixture. All supports for fixtures shall be adequate to support weight of the fixtures. All visible hanging devices and appurtenances shall have the same finish as the fixture unless specifically indicated otherwise.
- H. Coordinate with the work of other trades to determine modifications required to make fixtures suitable for ceilings as installed and verify the types of ceiling construction prior to fixture fabrication. Determine that the suspension method and the flange arrangement for the fixtures coordinates with the ceiling type and its suspended system. Fixtures which are shipped to the project and do not fit, or which otherwise do not match the ceiling system, shall be returned for correction at no additional cost.
- I. Installation shall include receiving, checking, storage in a safe and approved area until they are required for installation, unpacking, assembly of separate fixture components where

required, and complete wiring and connection including the provision of associated wiring and connection devices such as fittings, hangers, aligners, box covers, and similar hardware which may be required for certain fixtures, but are not detailed or scheduled with the fixtures.

- J. Plaster frames or mounting frames shall be provided for all fixtures which require them and shall be suitable for the ceiling construction in which they will be installed.
- K. Trim rings shall be painted to match the finish of the adjacent ceiling surface.
- L. Fixtures in equipment rooms shall be positioned clear of equipment interference and yet provide adequate light for working around the equipment.
- M. All lighting fixtures, when installed, shall be set free of light leaks, warps, dents, or other irregularities.
- N. Pendant-type fixtures shall be hung at heights as required, and as shown on the Drawings.
- O. In certain areas shown on the Drawings, the locations of fixtures are approximate only and the exact locations and pendant lengths will be determined by the Architect.
- P. If permanent lighting fixtures are to be used in lieu of temporary lighting facilities during the construction period, this shall be done only as permitted by the Owner's Representative, and fixtures shall be cleaned at the time of turnover to the Owner.
- Q. Lighting fixtures for general illumination, emergency lighting, and exterior lighting, shall be complete with all required accessories and attachments.
- R. Fixtures shall bear UL label and shall be wired and installed in full compliance with applicable codes.
- S. The omission of a type or quantity in the Interior Lighting Fixture Schedule on the Contract Drawings shall not relieve the Contractor of the responsibility of installing all required fixtures, of proper type, as shown on the Drawings.
- T. Fixtures shall be recessed, surface, or pendant type, as specified and shall include sockets, diffusers, ceiling canopies and stems, hickeyes, and all other necessary accessories.
- U. Where suspended ceilings with steel channels occur, outlets and fixtures shall be supported on members resting on the channel framework. In no case shall fixtures be supported from plasterboard, plaster, or acoustic material.

3.2. GENERAL INSTALLATION OF FIXTURES

- A. Install interior lighting fixtures at locations and heights as indicated, in accordance with fixture manufacturer's written instructions, applicable requirements of NEC, NECA's Standard of Installation, NEMA Standards, and with recognized industry practices to ensure that lighting fixtures fulfill requirements.
- B. All recessed fixtures mounted in dry wall or plaster ceilings shall be complete with a suitable plaster frame or trim ring. All fixtures shall be mounted on or in ceilings in

accordance with published recommendations of the manufacturers using bar or swing-way hangers, etc. These items shall be furnished as part of the fixture whether called for by catalog number or not.

- C. All fixtures shall be installed in strict accordance with NEC Article 410 and shall properly and suitably support the weight of any fixture installed. All fixtures shall be supported independently of ceiling suspension system being attached to building structure.
- D. Every lighting fixture shall be of the type for the ceiling construction in or on which it is to be installed. It shall be the Electrical Contractor's responsibility to coordinate this with the Ceiling Contractor.
- E. Install surface-mounted fixtures properly to eliminate light leakage between fixture frame and finished surface. Apply small bead of caulk or silicone around perimeter of fixture to conceal gaps between fixture and finished surface.
- F. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B, and the National Electrical Code.

3.3. CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Ground equipment per NEC and manufacturer's instructions.
- C. Exit signs and emergency lighting units shall be connected to the un-switched (hot) phase conductor of the lighting branch circuit serving the space, such that exit signs are illuminated at all times and emergency lighting units turn on upon loss of normal power. Switches, control panels, and relays controlling lights in the space shall not affect the operation of exit signs and emergency lighting units.

3.4. FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Advance Notice: Give dates and times for field tests.
- C. Provide instruments to make and record test results.
- D. Tests: As follows:
 - 1. Verify normal operation of each fixture after installation.
 - 2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
 - 3. Verify normal transfer to emergency source and retransfer to normal.
 - 4. Report results in writing.

- E. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.
- F. Corroded Fixtures: Replace during warranty period.

3.5. CLEANING AND ADJUSTING

- A. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer.
- B. Adjust aimable fixtures to provide required light intensities.
- C. Touch up luminaire finish at completion of work.
- D. Replace all light sources and/or electrical drivers that fail within three (3) months of Substantial Completion.

3.6. DEMONSTRATION

- A. Provide a minimum of four (4) hours of training and demonstration of luminaire operations, adjustment, and maintenance.

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DIVISION 26 SECTION 265562
PERFORMANCE PLATFORM LIGHTING
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SECTION 265562 PERFORMANCE PLATFORM LIGHTING

PART 1. GENERAL

1.1. RELATED DOCUMENTS

- A. Drawing 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 Electrical Contractor shall furnish all conduit, wire, connectors, hardware, and other incidental items necessary for the complete and proper operation of the lighting control system and rigging systems.
- B. Specification Includes
 - 1. Systems:
 - a. Smart Track and Smart Theatrical Dimmers
 - b. Lighting Fixtures and Support Hardware
 - 2. Provision of materials, components, modifications, assemblies, equipment, and services as specified herein. These include, but are not limited to:
 - a. Verifications of site dimensions and conditions
 - b. Manufacture Submittals (6 copies min)
 - c. Electrical Drawings for permit as required by contract documents
 - d. Engineering of equipment and systems as required by contract documents
 - e. Scheduling, sequencing, and coordination of sub-contractors
 - f. Installation and onsite supervision for all equipment and systems specified herein.
 - g. Testing and demonstration of equipment and systems as specified herein.
- C. The requirements of Division 26 apply to all the electrical work included in this section, unless specifically directed otherwise.

1.3. ALTERNATES

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

1.4. REFERENCE STANDARDS

- A. National Fire Protection Associations (NFPA) Publications: National Electrical Code, NFPA 70.
- B. Underwriters Laboratories Standards:
 - 1. UL498, Electrical Attachment Plugs and Receptacles

- 2. UL508, Electrical Industrial Control Equipment
- 3. UL891, Dead-Front Electrical Switchboards
- 4. UL1573, Stage and Studio Lighting Units
- C. United States Institute for Theatre Technology Standard: DMX512/1990, Digital Data Transmission Standard for Dimmers and Controllers
- D. United States Institute for Theatre Technology Standard: CAN
- E. Institute of Electrical and Electronics Engineers, Inc:
 - 1. Standard: 802.3
 - 2. Standard: 802.11 b or g
- F. American National Standards Institute (ANSI)
- G. International Building Code (IBC)
- H. State and/or Local Electrical Code

1.5. FIELD CONDITIONS

- A. All bidders shall fully inform themselves of the conditions under which the work is to be performed. No additional compensation shall be allowed for any labor or materials that the bidder could have been fully informed of prior to the bid date.

1.6. SAFETY

- A. The systems, and all components, shall conform to all applicable code requirements and shall be in conformance with industry standards of operation and practices. All materials, arrangements, and procedures shall comply with applicable code requirements, allowing the users to arrange and operate a safe assembly and working environment audience and user personnel.

1.7. QUALITY ASSURANCE

- A. Manufacturer shall be one who has been continuously engaged in the manufacturer of lighting control equipment for a minimum of ten years.
- B. The manufacturer shall have a factory authorized stocking service center with at least two full time service technician on staff located within 100 miles of the job site. In addition, the manufacturer shall have a toll free 24-hour hotline with a maximum response time of 20 minutes, 24 hours a day and 365 days a year.
- C. All equipment, where applicable standards have been established, shall be built to the standards of Underwriters Laboratories, Inc., the National Electrical Code and the United States Institute for Theater Technology. Permanently installed power distribution equipment shall be UL and C-UL Listed, and/or CE marked (where applicable) and bear the appropriate labels. Portable equipment such as consoles and fixtures shall be UL and

C-UL Listed, ETL Listed and/or CE marked (where applicable) and bear the appropriate labels.

1.8. SUBMITTALS

- A. Project Data: For each product specified, indicating configurations, finishes, and dimensions.
- B. Shop Drawings: Contractor shall prepare and submit shop drawings including, but not limited to, floor plans indicating equipment locations to ensure coordination with other Divisions, as well as wiring diagrams indicating power and control requirements for luminaires, dimmers, etc.
- C. Contractor shall furnish any additional information, including equipment demonstration, as required by the Architect/Engineer to verify compliance with specifications.

1.9. WARRANTY

- A. Provide warranty for system and equipment to be free of defective components, faulty workmanship, and improper adjustment for a min period of two (2) years from the date of acceptance by the Owner's Representative. Paint and exterior finishes are excluded from this warranty but must be in a new condition upon acceptance.
- B. Replace items showing evidence of defective materials or workmanship within thirty (30) days after written notification.
- C. Rectify conditions that might present a hazard to human life, well-being, or property within forty-eight (48) hours.

1.10. EXTRA MATERIALS

- A. Provide 10% spare lamps, but no less than one (1), of each lamp type provided.

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. Altman Stage Lighting Company, Inc.
 - 2. Chauvet
 - 3. Electronic Theatre Controls, Inc.
 - 4. Lehigh Lighting
 - 5. **Strand Lighting**

2.2. “SMART TRACK” LIGHTING SYSTEM

A. General

1. The Lighting System shall consist of high quality aluminum lighting track with integral data distribution, rugged multi adapters to support fixtures and to transfer power and data from the track to devices mounted on the track system, and controllable devices such as lighting fixtures. The Lighting System shall be the Smart-Track System as manufactured by Altman Stage Lighting, or approved equal.
2. Track Sections shall distribute (1) or (2) 20 amp 120 VAC power circuits and shall include integral distribution of DMX-512A (ANSI E1.11-2004) and RDM (ANSI E1.20-2006) control signals to lighting fixtures and controllable devices mounted on the Smart Track. Connection of a “smart” lighting fixture to the Smart Track shall automatically connect it to the data network.
3. The Lighting System provide for the connection and control of a variety of load types, including:
 - a. Quartz-Halogen
 - b. Low Voltage
 - c. CDM (Metal Halide)
 - d. LED (Light Emitting Diode)
4. Each load or fixture in the lighting system shall incorporate its own dimmer, relay, or LED driver. Submittals for systems requiring installation and provision of dimmer panels, relay panels, or external LED Drivers shall be rejected without review.
5. Each load or device connected to the Lighting System shall be independently controlled via a unique digital address. Control zones shall be determined on a fixture by fixture basis, shall be field changeable, and shall be completely independent of circuitry and wiring used to power the load.
6. The Lighting System shall be compatible with any Lighting Controller fully compliant with the DMX-512A (ANSI E.1.11-2004) standard. Connection points shall be provided for both wired and wireless connection of controls to the Lighting System.
7. The Lighting System shall have a complete line of components to join data and electrify separate track pieces, including:
 - a. Live and Dead End Feeds
 - b. In line couplers
 - c. Feed thru connectors
 - d. L turns (left and right)
 - e. X-connectors
 - f. Data Terminators
8. All components of the Lighting System shall be U.L. or ETL listed.

B. Components

1. Track System

- a. Track Sections shall include one (1) or two (2) separately switchable circuits with independent and dedicated neutral conductors as well as associated couplers, feeds, and terminators.
- b. Track Sections shall include a data bus track with two (2) 22-gauge nickel plated copper conductors integrated into the bottom slot of the track for distribution of DMX-512A and RDM control signals.
 - i. Data can be accessed anywhere along the track.
 - ii. Adaptors without bus contacts also can use the 2 circuit track with data bus, but without DMX-512A and RDM functions.
- c. Track Sections shall consist of the following:
 - i. An extruded aluminum housing measuring 1-1/4" x 1-3/4". Track sections shall be available in precut lengths of 4', 8', or 12'.
 - ii. The extruded aluminum housing shall also function as ground.
 - iii. Track sections shall include two inserted plastic profiles carrying up to four (4) embedded 12-gauge copper conductors.
- d. Mounting and Installation:
 - i. It shall be possible to field cut Track Sections to necessary lengths for each project and location. It shall not be necessary to cut back or bend back the conductors after field cutting of track sections.
 - ii. Track Sections shall have pre-punched holes for mounting every 8" on center.
 - iii. The top of the track shall have an extruded profile to allow for the mounting a manufacturer supplied bracket/hanging supports for connecting with contractor supplied stem, cable, or threaded rod.
- e. Track Sections shall be available in white, black, or silver finish.

2. Multi Adapter

- a. Multi Adapters shall be rugged, highly compact components that connect lighting fixtures and other controllable devices to the Smart Track system.
- b. Multi Adapters shall include a double lock mechanism allowing for connection of 22 lbs maximum spotlights:
 - i. One mechanical lock shall securing the adapter to the track.
 - ii. One mechanical lock shall connect the power contacts and shall be sued for selecting circuit 1, circuit 2 (2-circuit tracks only), or "off".
- c. Multi Adapters shall include the following features:
 - i. Wiring terminals and nickel plated spring contacts.
 - ii. Approval and listing for 120V.
 - iii. Integral ground contact and on/off switch.
 - iv. Support a maximum load up to 22 lbs.
- d. Multi Adapters shall be constructed of self-extinguishing polycarbonate according to class V0.
- e. Multi Adapters shall be available in white, black, or silver finish.

3. Luminaires

- a. Fixtures for use on the DMX track system shall consist of a family of luminaires designed with an on board DMX interface and an installed Multi Adapter designed to mechanically hang, power, and feed data.
- b. Fixtures shall be of three types; LED, Quartz, and Metal Halide
 - i. LED color changing luminaires shall be available as three types; fixed color temperature white, color temperature control white, or color mixing (RGB or RGBA). LED fixtures shall feature integral power supplies, drivers, and DMX interface and pre-programmed modes.
 - ii. Quartz fixtures shall have an integral, on board DMX controlled phase-forward (leading edge) dimmer compatible with incandescent, low voltage, and certain phase-dimmable LED loads.
 - iii. Metal Halide (CDM) fixtures shall have an on board DMX on/off relay. Relay rated for 70 watts maximum.
- c. DMX addressing for all system fixtures shall be conducted via manual setting of the rotary dials for Dimmer and CDM luminaires and push button for LED or via RDM from a remote location with a Remote Authorization Device.
 - i. The units shall be supplied with two dip switches to change modes from DMX, RDM, manual over ride dimmer control and full on power mode.
 - ii. All fixture dip switches and dials will be concealed by a latch that requires the use of a screwdriver to access and make changes.
 - iii. Luminaires shall retain their identity and programming, even when moved to a new location and the comma.
 - iv. Data input on all fixtures will have high voltage protection circuitry.
- d. Fixtures may be connected to the system at any point along the track.
- e. Fixtures equipped with Multi Adapters without data bus contacts may be used to connect standard lighting fixtures to the power distributed by the track, without connection to control functions.
- f. All fixtures shall be U.L. or ETL listed.

C. Data Distribution, Wiring, and Connection

- 1. Control wiring shall be suitable for transport of DMX-512A (ANSI E1.11-2004) and RDM (ANSI E1.20-2006) control information between the output of the lighting control system and smart track sections and/or other DMX-controlled devices.
- 2. Maximum overall length of each control segment as measured from the output of the control system (and related RDM compatible signal splitters or amplifiers), including control cable and smart track sections, shall not exceed 1000’.
- 3. Control segments shall be installed as daisy chain topology only. “T-tap” or “star” type installations shall not be allowed.
- 4. Each control segment shall be terminated with a 120ohm resistor as specified by DMX-512A (ANSI E1.11-2004) Standard.

5. Maximum number of recommended devices per segment shall not exceed (32). Each individual Luminaire with associated driver/dimmer/ relay shall count as ¼ device.
 6. Contractor shall furnish and install suitable DMX-512A (ANSI E1.11-2004) control cable as recommended by the manufacturer of the control system procured and installed for this project.
- D. Provide Smart Track sections, hardware, luminaires, and accessories as required to execute the designs shown on Contract Documents.

2.3. ELLIPSOIDAL SPOTLIGHTS

A. Description:

1. The instrument shall be an ellipsoidal spotlight as manufactured by Altman Stage Lighting, Inc., or approved equal.

B. Physical:

1. The unit shall be constructed of rugged, die cast aluminum, free of burrs and pits, finished in high temperature epoxy paint. Architect shall select luminaire finish from standard factory finish options. Tools shall not be required for either lamp alignment or cleaning the reflector or lens

C. Performance:

1. The unit shall be precision engineered to use a high intensity tungsten halogen lamp to deliver an even, intense field with cosine distribution.
2. The unit shall provide, but not be limited to:
 - a. 18, 23, 28, 38 and 48 degree field angles
 - b. High-quality pattern imaging
 - c. Sharp shutter cuts without halation
 - d. Shutter warping and burnout in normal use shall be unacceptable
 - e. Adjustable hard and soft beam edges
3. The unit shall be UL and cUL listed and so labeled.

D. Lamp:

1. The high efficiency lamp shall be a high intensity tungsten halogen lamp, rated at 375W, 2900K color temperature, 1,500 hour life and 8,000 lumens. The lamp shall mount axially within the reflector.

E. Basis of Design:

1. Altman Catalog No. 3.5QY-6-MT, or approved equal.

2.4. SMART THEATRICAL DIMMERS

A. General:

1. The instrument shall be a Smart Theatrical Dimmer – STD as manufactured by Altman Stage Lighting, Inc., or approved equal.

B. Dimmer:

1. Compatible with all phase-forward dimmable loads 600 watts, 120 volt.
2. Mount directly to the hanging yoke of performance lighting fixtures.
3. DMX-512A and RDM compatible via integrated 5-pin XLR connectors.
4. Integrated 5 amp, 120 volt AC push button breaker.
5. Convection cooled, no fans.

C. Basis of Design:

1. Altman Catalog No. STD-600, or approved equal.

2.5. COLOR MIXING LIGHT EMITTING DIODE (LED) STRIP FIXTURES

A. General:

1. The fixture shall be a six-foot long color-mixing high-intensity RGBA LED strip fixture with DMX control of intensity and color. The fixture shall be a Spectra Strip SS-STR-6-RGBA-BK as manufactured by Altman Stage Lighting, Inc., or approved equal.
2. All LED fixtures shall be provided by a single manufacturer to ensure compatibility

B. Physical:

1. The fixture shall be contained in a rugged extruded and sheet aluminum housing, free of burrs and pits.
2. Power supply, cooling and electronics shall be integral to each unit.
3. The unit shall ship with:
 - a. Theatrical-style hanging yoke as standard
 - b. 3-meter power lead with molded Edison connector as standard

C. Electrical:

1. The fixture shall be equipped with 120V to 240V 50/60 Hz internal power supply.
2. The fixture requires power from a constant or switched source.

3. DMX-512A and RDM via 5-pin XLR male and female receptacles for each light engine.
4. 8 or 16 bit resolution is selectable per light engine per fixture.

D. LEDs

1. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.
2. 50,000 hour rated life.
3. Color mixing light engines utilize 4-color RGBA mixing system (red, green, blue, amber).

E. Accessories

1. Provide the following accessories for each fixture:
 - a. 95° x 25° spread lends (Catalog No. SS-STR-LSD-9525).
 - b. 5 pin DMX extension cable, lengths as required.
 - c. All mounting hardware for installation on pipe battens.

2.6. POWER DISTRIBUTION CONNECTOR STRIPS

A. General

1. Steel connector strips for power distribution and data distribution to control LED stage lighting fixtures.
2. Provide Altman Lighting Catalog No. 450-PBU-1-515R-XLR-5F, or approved equal.

B. Construction

1. Rugged 18 gauge steel construction with 14 gauge end caps and joiners. Center holes on end caps for conduit fittings.
2. Flush-mount and/or pigtail connectors for power distribution to luminaires. Connector types and rating to match fixtures.
3. Data management for distribution of DMX-512/RDM to distribution dimmers, and/or LED luminaires.
4. All din rail mounted compenents.

C. Electrical

1. Circuits in connector strip are pre-wired to a junction box, which contains din-rail mounted terminal strips.
2. Din rail mounted screwless spring terminals for terminations of 20 ampere loads.

Screw terminals for wiring above 20 amperes.

3. Power receptacles to match plugs of lighting fixtures.
4. Data receptacles shall be flush-mounted female 5-pin XLR (DMX) for distribution of DMX-512/RDM signals.

2.7. LIGHTING CONSOLE AND ACCESSORIES

A. General

1. The lighting control shall be a microprocessor-based system specifically designed to provide complete control of stage, studio, and entertainment lighting systems.
2. The lighting console shall be capable of controlling the light sources indicated herein and/or in the “Platform Lighting Fixture” schedule on the contract drawing, indicating but not limited to LED light sources.
3. A maximum of 288 cues.

B. Interface Options

1. The console shall support a variety of local interfaces.
 - a. AC input
 - b. DMX out
 - c. MIDI Out
 - d. MIDI In
 - e. One VGA output connector.

C. Physical

1. All operator controls and console electronics for a standard system shall be housed in a single desktop console.
2. Console power shall be 95-240V AC at 50 or 60 Hz, supplied via a detachable power cord.

2.8. DMX ISOLATOR/SPLITTER

A. General:

1. Ensures optically safe DMX line splitting and isolation of DMX-512. Accepts a DMX control signal from the console and provided isolation between the control input and additional DMX feeds for dimmer packs and racks, lights, etc.

B. Inputs/Outputs

1. Control Input – Male 5-pin XLR DMX
2. Pass Thru – Female 5-pin XLR DMX (unbuffered)

3. Isolated Outputs – Quantity as required for system operation.
 - C. Electrical Characteristics
 1. IEC flush mounted male, power cord included.
 2. External switch for 110/220 volt operation.
 3. Miniature fuse rated at 2 amperes for overcurrent protection.
 - D. Physical
 1. Standard E.I.A. rack mountable.
 2. 1.75" H x 19" W x 7"D
 - E. Provide LDMX series as manufactured by Leprecon, or approved equal.
- 2.9. THEATRICAL PIPE SUPPORT
- A. Provide 1-1/2" nominal diameter, schedule 40 pipe supports for stage lighting fixtures. Lengths as required to accommodate lighting fixture layout indicated on the Drawings.
 - B. Construction:
 1. Battens shall be made from seamless pipe with a matte black finish.
 2. Battens up to 21'-0" long shall be supplied as a single-piece; longer battens shall be provided with 18" long internal splice sleeves.
 3. Battens shall have safety yellow vinyl end caps.
 - C. Hardware and Accessories:
 1. Provide all hardware and accessories, including but not limited to clamps, connectors, cables and supports for a complete theatrical lighting fixture installation.
 - D. Pipe battens shall be J.R. Clancy Catalog No. 015-67R, or approved equal.

PART 3. EXECUTION

3.1. INSTALLATION

- A. It shall be the responsibility of the Contractor to receive and store the necessary materials and equipment for installation of the dimming systems. It is the intent of these specifications and plans to include everything required for proper and complete installation and operation of the performance systems, even though every item may not be specifically mentioned. The Electrical contractor shall deliver on a timely basis to other trades any equipment that must be installed during construction.
- B. The Contractor shall be responsible for field measurements and coordinating physical size

of all equipment with the architectural requirements of the spaces into which they are to be installed.

- C. The Contractor shall install electrical equipment in accordance with manufacturer's approved shop drawings.

3.2. START-UP AND DEMONSTRATION

- A. A qualified Service Representative employed full time by the manufacturer shall visit the job site after the installation is complete and prior to the energization of the system to inspect, test and adjust the system.
- B. Instruction shall be provided for the Owner's representatives in the operation and maintenance of the system. Provide a minimum of 4 hours of instruction, with a minimum of 14 days written notice to the Contractor.

3.3. MANUFACTURER'S WARRANTY

- A. Manufacturer shall warrant products under normal use and service to be free from defects in materials and workmanship for a period of two years from date of delivery.
- B. Warranty shall cover repair or replacement of such parts determined defective upon inspection.

3.4. CLOSE OUT DOCUMENTATION

- A. The Contractor shall provide two sets of as-builts drawings which shall include marked up submittal drawings and electronic copies of all operational and maintenance manuals and system configurations.

END OF SECTION

DIVISION 26 SECTION 26 56 00
EXTERIOR LIGHTING
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SECTION 26 56 00 - EXTERIOR 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.
- B. Related Sections include the following:
 - 1. Division 26 Section 265100, “Interior Lighting”, for lighting fixtures installed on the exterior walls of the building.
 - 2. Division 26 Section 260943, “Network Lighting Controls” for lighting control systems controlling exterior lighting.

1.2. ALTERNATES

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

1.3. SUMMARY

- A. This Section includes exterior lighting units with luminaires, light sources, poles/support structures, and accessories.

1.4. DEFINITIONS

- A. CCT: Correlated Color Temperature.
- B. CRI: Color Rendering Index.
- C. DLC: Design Lights Consortium.
- D. IDA: International Dark-Sky Association.
- E. IES: Illuminating Engineering Society.
- F. LED: Light Emitting Diode.
- G. Lighting Unit: A luminaire or an assembly of luminaires complete with a common support, including pole, post, or other structure, and mounting and support accessories.
- H. LPW: Lumens per Watt.
- I. Luminaire (Light Fixture): A complete lighting device consisting of light source(s) and driver(s), when applicable, together with parts designed to distribute light, to position and protect light sources, and to connect light sources to power supply.

1.5. SUBMITTALS

- A. Product Data: Provide dimensioned and detailed drawings in booklet form with separate sheets for each type of lighting unit indicated, arranged in order of lighting unit type and designation. Include data on features, accessories, finishes, and the following:
1. Materials and dimensions of luminaires and poles.
 2. Certified results of independent laboratory tests for fixtures and lamps for electrical ratings and photometric data. Include manufacturer and model number of fixture being submitted.
 3. Lamp ANSI designation, initial and mean lumen output, average-rated hours of lamp life and lamp mortality curve, and color temperature and color rendering index.
 4. Ballast ANSI designation; electrical characteristics, including voltages, lamp and line operating and starting amperes, watts and watt losses, percent of allowable line voltage variation range and lamp crest factor; minimum lamp starting temperature; and normal and maximum ballast operating temperature.
 5. Ballast CBM approval and UL listing, volts, lamp and input amperes, input watts, and minimum lamp starting temperature.
 6. Poles and standards dimensions, details of hand holes and wire entries, mast or bracket arms and connection to poles, wind load and deflection, and finishes.
- B. Shop Drawings: Anchor bolt templates keyed to specific poles and certified by manufacturer.
- C. Samples for Verification: For lighting units or luminaires designated for sample submission in this Specification.
1. Lamps: Specified units installed.
 2. Ballast: 120 V model of specified ballast type.
 3. Finishes: For each finished metal used in support components
- D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- E. Record Documents: Accurately record actual location of each luminaire with the switching arrangements shown.
- F. Submit pole load calculations, including EPA wind load calculations, for all poles. Calculations shall include all pole-mounted devices including luminaires, call stations, handholes, directional signs, and banners. Refer to this Section, Paragraph “Fixtures” for additional information. Wind resistance calculations shall be certified by a Registered Professional Engineer.
- G. Submit point by point lighting calculations for layout shown on the Contract Drawings if utilizing lighting fixture(s) other than first-named fixtures in the “Exterior Lighting Fixture Schedule” on the Contract Drawings (Basis of Design). All calculations shall strictly comply with IES Standards. Indicate foot candle readings minimum 5'-0-inches on center along the horizontal plane.
- H. Maintenance Data: Submit maintenance data and parts list for each exterior lighting fixture

and accessory; including trouble-shooting maintenance guide. Include that data, product data, and shop drawings in a maintenance manual; in accordance with requirements of Division 01.

1.6. SAMPLES

- A. After shop drawing review and prior to release for manufacturing, the Contractor shall furnish one sample of each fixture in this Specification for which sample requirement is noted.
- B. Shipping: The samples shall be complete with specified lamps and compatible ballast, ready for hanging, energizing, and examining, and shall be shipped, prepaid by the Contractor, to the Engineer, or as otherwise advised.
- C. Two weeks from the date received shall be allowed for thorough examination of the samples by the Engineer.
- D. Return: Samples are returnable, the Contractor shall arrange for return, prepaid shipping, and pickup of each sample submitted.
- E. Samples must be actual working unit of materials to be supplied.

1.7. QUALITY ASSURANCE

- A. Luminaires and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for their indicated use, location, and installation conditions by a testing agency acceptable to authorities having jurisdiction.
- B. ANSI/ASTM Compliance: Comply with applicable requirements of ANSI C2, National Electrical Safety Code.
- C. FM Compliance: Units for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM.
- D. Comply with recommended practices of Illuminating Engineering Society (IES).
- E. All products shall comply with UL and shall be UL listed.
- F. Manufacturer's Qualifications: Firms regularly engaged in manufacture of exterior building lighting fixtures of types and ratings required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- G. Installer's Qualifications: Firm with at least three (3) years of successful installation experience on projects with exterior lighting fixture work similar to that required for the project.
- H. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Articles 25, 250, 410, and 501 as applicable to installation, and construction of lighting fixtures encompassed by this section.
- I. NEMA Compliance: Comply with applicable requirements of NEMA Standards

Publication No. LE 2 pertaining to lighting equipment.

- J. IES Compliance: Comply with IES RP-8, 19, 20, and PB-15 pertaining to exterior, parking, and roadway lighting practices and fixtures.
- K. UL Compliance: Comply with requirements of UL Standards, including Standards 486A and B, pertaining to exterior lighting fixtures. Provide exterior lighting fixture and components which are UL listed and labeled and comply with the following UL Standards:
 - 1. UL 1598 – Luminaires (Tri-national standard)
 - 2. UL 8750 – Light Emitting Diode (LED) Equipment for Use in Lighting Products
 - 3. UL 8753/ULC-S8753 – Standard for Field-Replaceable Light Emitting Diode (LED) Light Engines
 - 4. UL 8754/ULC-S8754 – Holders, Bases, and Connectors for Solid-State (LED) Light Engines and Arrays.
 - 5. UL 924 – Emergency Lighting and Power Equipment
- L. NFPA Compliance: Comply with applicable requirements of NFPA 78, Lightning Protection Code, pertaining to installation of exterior lighting fixtures.
- M. Code compliance is mandatory. Nothing in the Drawings and Specifications implies acceptance of work not conforming to these codes. Where work is shown to exceed minimum code requirements, comply with the Drawings and Specifications.
- N. Codes and Standards: Provide luminaires, poles, standards and appurtenances conforming to the following:
 - 1. American National Standards Institute (ANSI):
 - a. C2: National Electrical Safety Code.
 - 2. Conform to applicable sections of American Society for Testing and Materials (ASTM).
 - a. B429: Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
 - 3. Conform to applicable sections of Certified Ballast Manufacturer's Association (CBM) Standards for Fluorescent Lamp Ballasts.
 - 4. National Electrical Manufacturers Association (NEMA):
 - a. FA1: Outdoor Floodlighting Equipment.
 - b. OD3: Physical and Electrical Interchangeability of Photo Control Devices and Mating Receptacles.
 - c. SH5: Tubular Steel, Aluminum, and Prestressed Concrete Poles.
 - 5. Conform to applicable sections of National Fire Protection Association (NFPA) 70, National Electrical Code.
 - 6. Underwriters Laboratories, Inc. (UL):
 - a. 57: Electric Lighting Fixtures

7. Conform to all local requirements for maximum pole heights and pole setback distances from property lines.

1.8. DELIVERY, STORAGE, AND HANDLING OF POLES

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay resistant treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- C. Retain factory applied pole wrappings on poles until just before pole installation. Handle poles with web fabric straps.
- D. Deliver exterior lighting fixtures in factory-fabricated containers or wrappings, which properly protect fixtures from construction debris and physical damage.
- E. Store exterior lighting fixtures in original wrappings in a clean dry space. Protect from weather, dirt, fumes, water, construction debris, and damage.
- F. Handle exterior lighting fixtures carefully to prevent damage, breaking, and scoring. Do not install damaged fixtures or components; remove units from site and replace with new.
- G. Sequence exterior lighting installation with other work to reduce possibility of damage and soiling of fixtures during the remainder of the construction period.

1.9. 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, signed by Manufacturer and Installer agreeing to replace external parts of luminaires and poles exhibiting a failure of finish as specified below. This warranty is in addition to, and not a limitation of, other rights and remedies Owner may have under requirements of the Contract Documents.
 1. Protection of Metal from Corrosion: Warranty against perforation or erosion of finish due to weathering.
 2. Color Retention: Warranty against fading, staining, and chalking due to effects of weather and solar radiation.
 3. Warranty Period: Manufacturer's standard, but not less than three years from date of Substantial Completion for poles, and not less than one year from date of Substantial Completion for luminaires.

1.10. EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. LED Circuit Boards: 1 for every 20 of each type and rating installed. Furnish at

- least one of each type.
- 2. Glass and Plastic Lenses and Covers: 1 for every 20 of each type and rating installed. Furnish at least one of each type.
- 3. Electronic LED Drivers: 1 for every 20 of each type and rating installed. Furnish at least one of each type.
- 4. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

1.11. COORDINATION

- A. Furnish bolt templates and pole mounting accessories to installer of pole foundations.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include the products indicated on the “Exterior Lighting Fixture Schedule” on the Contract Drawings.
- B. Data listed and model numbers shown in this Specification for each fixture type indicate minimum requirements; and no exceptions will be made.
- C. Lighting fixtures shall be as set forth in this Specification on the Drawings. Substitutions of other fixtures which are truly equivalent or superior to those specified, provided the bid price is not increased, shall be given every reasonable consideration. However, any assumption by a Bidder or Vendor that an alternate fixture is “equal” is made at his own risk.

2.2. GENERAL PRODUCT REQUIREMENTS

- A. Comply with IESNA RP 8 for parameters of lateral light distribution patterns indicated for luminaires.
- B. Metal Parts: Free from burrs, sharp corners, and edges.
- C. Sheet Metal Components: Corrosion resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.
- D. Housings: Rigidly formed, weather and light tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- E. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position. Provide for door removal for cleaning or replacing lens. Arrange to disconnect ballast when door opens.
- F. Hardware: All hardware (e.g. screws, nuts, washers, latches, etc.) for fixtures in damp/wet locations shall be stainless steel, unless otherwise indicated on the Drawings.

- G. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
- H. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- I. Lenses and Refractors: Materials as indicated. Use heat and aging resistant, resilient gaskets to seal and cushion lens and refractor in luminaire doors.

2.3. LUMINAIRES

- A. Refer to “Exterior Lighting Fixture Schedule” on the Contract Drawings.

2.4. LUMINAIRE SUPPORT COMPONENTS

- A. Description: Comply with AASHTO LTS 3 for pole or other support structures, brackets, arms, appurtenances, base, and anchorage and foundation.
- B. Wind Load Strength of Total Support Assembly: Adequate to carry support assembly plus luminaires at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of 100 mph (160 km/h) with a gust factor of 1.3. Support assembly includes pole or other support structures, brackets, arms, appurtenances, base, and anchorage and foundation. Strength Analysis: For each pole type and luminaire combination, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
- C. Finish: Match finish of pole/support structure for arm, bracket, and tenon mount materials.
- D. Mountings, Fasteners, and Appurtenances: Corrosion resistant items compatible with support components.
 - 1. Materials: Will not cause galvanic action at contact points.
 - 2. Mountings: Correctly position luminaire to provide indicated light distribution.
 - 3. Anchor Bolts, Nuts, and Washers: Hot dip galvanized after fabrication unless stainless steel items are indicated.
 - 4. Anchor Bolt Template: Plywood or steel.
- E. Provide poles with mast arms, brackets, and bases as indicated on the Drawings. Poles shall meet all requirements set forth in this Specification. Substitutions shall match exactly the characteristics of the pole specified in this Specification.
- F. Mast arms and pole-top mounting brackets for luminaires shall be manufactured specifically for the pole and luminaire submitted.
- G. Coordinate with pole and luminaire manufacturers for assembly details, wind loading and vibration analysis, and compatibility of materials for electrolysis free attachment and connection.

- H. Structural and Mechanical Design: Use a safety factor of 5.0 for static and dynamic loading of load bearing components, including cable.
- I. Concrete Pole Foundations: Size per Drawings. 4,500 psi compressive strength (minimum) at 28 days. Rub concrete to a smooth finish.
- J. Handholes: Provide manufacturer's reinforced type removable weatherproof gasketed coverplate. Provide welded 2-inch (12 mm) threaded grounding lug centered approximately 12 inches above the base. Handholes shall have a minimum clear access opening of 2-1/2-inches x 5-inches, unless otherwise noted.
- K. Base Cover: Each pole shall be provided with a base cover fabricated from the above-specified alloy. The cover shall be attached to the pole by means of tamperproof hardware.
- L. Anchor Bolts: All anchor bolts shall be fabricated of hot rolled special quality carbon steel with minimum 50,000 psi yield strength, or as recommended by Manufacturer. Bolts shall be furnished with nuts and washers. All bolts and hardware shall be zinc electro-plated after fabrication.

2.5. FINISHES

- A. Comply with NAAMM's Metal Finishes Manual for Architectural and Metal Products for recommendations for applying and designating finishes.
- B. Provide finishes on poles, mounting arms/brackets, and luminaires as indicated in the Lighting Fixture Schedule.

2.6. LED LIGHT SOURCES

- A. Manufacturers: Provide quality LED light sources by the manufacturers listed below. Off brand/generic light sources shall not be acceptable.
 - 1. Cree
 - 2. Osram
 - 3. Philips
 - 4. Samsung
- B. Correlated color temperature (CCT): as indicated on the "Exterior Lighting Fixture Schedule" on the contract drawings. Per ANSI C78.377.
- C. Light sources shall have a maximum deviation of 3-step Macadam Ellipses.
- D. Color rendering index (CRI): 80 CRI minimum.
- E. L70 rating shall meet or exceed value indicated on the "Exterior Lighting Fixture Schedule" on the contract drawings.
- F. Light sources shall be rated for low temperature applications (0°F, minimum).

2.7. LED ELECTRONIC DRIVERS

- A. Manufacturers: Provide quality LED electronic drivers by the manufacturers listed below. Off-brand/generic electronic drivers shall not be acceptable.
 - 1. Advance (Philips Lighting Electronics)
 - 2. eldo LED
 - 3. General Electric (GE) Lighting
 - 4. Lutron
 - 5. Osram Sylvania
 - 6. Samsung
 - 7. Universal Lighting Technologies, Inc.
- B. General Requirements:
 - 1. Suitable for operating type and quantity of LED sources indicated at full light output.
 - 2. No PCBs.
 - 3. Suitable for dry and damp locations.
 - 4. Starting temperature: 0 degrees Celsius.
 - 5. 50,000 hour (minimum) design life.
 - 6. Class 2 output UL recognized to UL and CSA requirements.
- C. Electrical Requirements:
 - 1. 0-10V dimming standard.
 - 2. Power Factor: 90 percent (0.9) minimum.
 - 3. Total Harmonic Distortion (THD): Less than 20 percent.
 - 4. Sound Rating: A.
 - 5. Short circuit and overload protection standard.
 - 6. Inherent thermal protection standard.
- D. Listings:
 - 1. ANSI/UL 8750
 - 2. ANSI C62.41: Category A for transient protection.
 - 3. ANSI C82.16
 - 4. FCC Part 15: Non-consumer equipment EMC.
 - 5. UL 1310: Standard for Class 2 Power Units.
- E. Warranty:
 - 1. Minimum five-year warranty.

2.8. SPLICES, TAPS

- A. All splices underground in hand holes or other wet locations shall be waterproof and made with Scotchcast 85 Multi-Mold Splicing Kits, or approved equal.
- B. All taps in pole bases shall utilize insulated connectors as specified in Division 26 Section, “Conductors and Cables”.

- C. Tap wiring to luminaire shall incorporate Bus type HEB waterproof in line fuseholder with 12 AWG XHHW conductors as recommended by ballast manufacturer.
- D. Splices in hand holes shall be supported on bricks 8-inches above bottom of handhole. Splices shall be kept to a minimum and are prohibited in locations other than hand holes, pull boxes or lighting unit bases, except for retaining circuitry of existing underground wiring where existing poles or wiring are distributed.

PART 3. EXECUTION

3.1. EXAMINATION

- A. Examine areas and conditions under which roadway, parking and outdoor lighting fixtures are to be installed and substrate which will support lighting fixtures. Notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

3.2. FIELD COORDINATION

- A. The Contractor shall be responsible for all field coordination, including verification of property lines, right of ways and other utilities.
- B. Contractor shall locate poles and underground conduits within property lines. Contractor shall locate poles in compliance with local setback requirements.

3.3. INSTALLATION

- A. Concrete Foundations: Construct concrete foundations with 4,000 psi (minimum), 28-day concrete.
 - 1. Comply with details for reinforcement and for anchor bolts, nuts, and washers. Verify anchor bolt templates by comparing with actual pole bases furnished.
 - 2. Finish for Parts Exposed to View: Trowel and rub smooth.
- B. Install poles in compliance with ANSI C2, with Manufacturer's written instructions and as follows:
 - 1. Use web fabric slings (not chain or cable) to raise and set poles.
 - 2. Mount pole to foundation with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
 - 3. Secure poles level, plumb, and square. Provide shimming and grouting of pole base to maintain luminaire in a true vertical position.
 - 4. Grout void between pole base and foundation. Use nonshrinking or expanding concrete grout firmly packed in entire void space.
 - 5. Use a short piece of 1/2 inch (13 mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- C. Luminaire Attachment with Adjustable Features or Aiming: Attach luminaires and supports to allow aiming for indicated light distribution.

- D. Lamp luminaires with indicated lamps according to manufacturer's written instructions. Replace malfunctioning lamps.
- E. Install exterior lighting fixtures at locations and heights as indicated in accordance with fixture manufacturer's written instructions, applicable requirements of NEC, NECA's Standard of Installation, NEMA Standards, and with recognized industry practices to ensure that lighting fixtures fulfill requirements.

3.4. UNDERGROUND DUCT LINES

- A. Duct lines shall be polyvinylchloride (PVC) heavy wall plastic ducts for installation without concrete encasement.
- B. Conductor AWG size shall be as indicated on the drawings, minimum 10 AWG. Conductors shall be type THW. Provide for each lighting branch circuit shown on the Contract Drawings, a separate green grounding conductor sized in accordance with NEC.
- C. Duct lines shall be installed in a trench minimum 24 inches below grade. Trench shall be cleaned of all rock, gravel or debris larger than 1/4 inch diameter. Duct lines shall rest on minimum 3-inch clean sand bed and shall have minimum 3 inches clean sand over cover. Trench earth backfill shall be free of rock, gravel or other debris. Open trenches shall be limited to 100 linear feet before backfilling.
- D. Metal conduit sleeves of sufficient size shall be installed in concrete lighting standard bases to allow the entry/exit of branch circuit wiring. Sleeves shall be capped with bushings.
- E. All elbows and all ducts installed above grade shall be rigid galvanized steel.

3.5. CONNECTIONS

- A. Ground equipment: 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.
- B. Ground metal poles/support structures and fixtures according to Division 26 Section 260526, "Grounding and Bonding for Electrical Systems".
 - 1. Bond metallic components of lighting fixtures, poles, and foundations. Connect luminaires to grounding conductors routed with associated branch circuit phase and neutral conductor(s) and to grounding electrode with 4 AWG conductor.
 - 2. Provide 10-foot (3-m) driven ground rod at each pole, exothermically welded to grounding conductor.

3.6. FIELD QUALITY CONTROL

- A. Inspect each installed unit for damage. Replace damaged units.
- B. Advance Notice: Give dates and times for field tests.
- C. Provide instruments to make and record test results.

- D. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with power source, and as follows:
 - 1. Measure light intensities at night if specific illumination performance is indicated. Use photometers with calibration referenced to NIST standards.
 - 2. Check intensity and uniformity of illumination.
 - 3. Check electronic LED drivers and circuit boards for proper operation.
- E. Prepare a written report of tests, inspections, observations and verifications indicating and interpreting results.
- F. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.
- G. Set, adjust, and aim adjustable fixtures at night. Repeat procedure until units provide illumination acceptable to the Owner.

3.7. CLEANING AND ADJUSTING

- A. Clean units after installation. Use methods and materials recommended by manufacturer.
- B. Adjust aimable luminaires and luminaires with adjustable lamp position to provide required light distributions and intensities, in night test of system. Verify that measured illuminance values comply with isolux plot diagram values and point-by-point calculations.
- C. Touch up damage to finishes.

3.8. DEMONSTRATION

- A. Provide a minimum of four (4) hours of demonstration of luminaire operation.
- B. Upon completion of installation of exterior lighting fixtures and associated electrical supply circuitry, apply electrical energy to circuitry to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

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-C.0: Generic Telecommunications Cabling for Customer Premises.
 - 2. ANSI/TIA-568-C.1: Commercial Building Telecommunications Cabling Standard
 - 3. ANSI/TIA-568-C.2: Balanced Twisted Pair Cabling and Components Standard
 - 4. ANSI/TIA-568-C.3: Optical Fiber Cabling Components Standard
 - 5. ANSI/TIA-569-B: Commercial Building Standard for Telecommunications Pathways and Spaces
 - 6. ANSI/TIA-570-B: Residential Telecommunications Cabling Standard
 - 7. ANSI/TIA-606-A: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
 - 8. ANSI-J-STD-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
 - 9. ANSI/TIA-758-A: Customer-Owned Outside Plant Telecommunications Cabling Standard
 - 10. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
 - 11. 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. Contractor shall outfit all telecom rooms according to T Drawings. Termination and distribution fields shall be installed according to manufacturer's guidelines and industry standards.
 - 2. TR and TER layouts shall be approved by Technology personnel prior to installation of cabling, pathways or termination hardware.
- B. Performance Requirements
 - 1. Materials 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.
4. LEED Submittals
 - a. Product data for Credit IEQ 4.1: For adhesives and sealants applied within the building waterproofing envelope, documentation including printed statement of VOC content in g/L.
 - b. Product data for Credit IEQ 4.2: For paints and coatings applied within the building water proofing envelope, documentation including printed statement of VOC content in g/L.
 - c. Product data for Credit IEQ 4.4: For composite wood installed in the building interior as equipment backer boards, documentation indicating no added urea formaldehyde resins.

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 the 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. The 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-builts shall be submitted in electronic CAD format and in hardcopy 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 is compatible with and has been coordinated with other portions of the Work.
 - f. 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 the 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. The installer's warranty shall guarantee workmanship for a period of two years, 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. Adhesives, sealants, paints and coatings applied within the building waterproofing envelope: Comply with low-emitting requirements in Division 01 Section "Indoor Air Quality Requirements."
- B. Composite wood installed in the building interior as equipment backer boards: Contain no added urea formaldehyde resins.
- C. 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 and inch ladder rack from racks/cabinets from corridor or other wire routing space where indicated on drawings.
- D. Basket Cable Tray:
 - 1. Cablofil EZTray CF 54/300 EZ or approved equivalent.
 - 2. 12" x 4" with associated mounting hardware.
 - 3. 18" x 4" with associated mounting hardware.
- E. J-Hooks
 - 1. 4" J-hooks
 - 2. 2" J-hooks
 - 3. J-Hooks shall be rated for low voltage cables.
 - 4. J-hooks shall be provided where cable tray and conduit are not present.
 - 5. J-hooks shall be installed on 5'-6' centers, not further apart.
- F. 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.
- G. Gang Boxes
 - 1. In-wall Gang Boxes for low voltage

- a. Single Gang Box: Minimum 2.75" wide X 3.75" high X 1.7" deep with ¾" and 1" knockouts.
 - b. In-wall Double Gang Box for low voltage: 4 Inch Back Knockout, 4 Inch Side Knockout, 4 Inch End Knockout, Length 3 ¾ Inches, Width 3 25/32 Inches, Depth 3 ½ Inches or comparable.
 - 2. Extra Deep in-wall gang boxes
 - a. 3 ¾" Deep, 2 3/16" Wide, 3 7/8" High
 - b. 4 Knockouts, 2 Per End
- H. Floor Boxes
 - 1. In-floor box
 - a. Coordinate all floor boxes and poke-through devices for telecom equipment with electrical installer.
 - b. Floor boxes shall meet latest UL standards for scrub water resistance
 - c. Six-Compartment Combination box similar to Wiremold EFB6s-OG.
 - 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. Poke through
 - a. Unit shall be similar to Wiremold Evolution Series with 5 gangs
- I. Distribution Backboard
 - 1. Plywood
 - a. ¾" 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 Main Grounding Busbar (PBB) and Telecommunications Grounding 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. Rack mounted power strip

1. Provide one 8 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 TGB 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 an appropriate fire stop system.

END OF SECTION 270500

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

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 devices 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.
- F. “Telecom Room (TR)” refers to an enclosed space for housing telecommunications equipment, cable terminations, and cross-connects. The room 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 systems found in the building.

1.3 REFERENCES

- A. Industry Codes, Standards and Methods shall be observed, including the following:
 - 1. ANSI/TIA-568.0-E: Generic Telecommunications Cabling for Customer Premises
 - 2. ANSI/TIA-568.1-E: Commercial Building Telecommunications Cabling Standard
 - 3. ANSI/TIA-568.2-D: Balanced Twisted Pair Cabling and Components Standard
 - 4. ANSI/TIA-568.3-D: Optical Fiber Cabling Components Standard
 - 5. ANSI/TIA-569-E: Commercial Building Standard for Telecommunications Pathways and Spaces
 - 6. ANSI/TIA-606-C: 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-LRM
 - viii. Fibre Channel 100-MX-SN-I
 - ix. Fibre Channel 100-SM-LC-L
 - x. Fibre Channel 200-MX-SN-I
 - xi. Fibre Channel 200-SM-LC-L
 - xii. Fibre Channel 400-MX-SN-I
 - xiii. Fibre Channel 400-SM-LC-L
 - xiv. Fibre Channel 1200-MX-SN-I
 - xv. Fibre Channel 1200-SM-LL-L
 - xvi. FDDI PMD ANSI X3.166
 - xvii. FDDI SMF-PMD ANSI X3.184
- b. All wiring, including copper and fiber optic employs 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 wired per 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 the 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 the 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 versions 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 cables in place. All cables 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 the 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. Communications outlets, faceplates, and accessories.
 - 2. Fiber optic cable, patch cables and terminations.
 - 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. 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.
- D. 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.”
- E. 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 2 years from the 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 cable 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: 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 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. The 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 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 services such 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. The 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 area without cable tray above false ceilings.

2.3 RACKS / CABINETS

A. Distribution Racks and Cabinets

1. Floor Mounted Free Standing 2 Post Racks

- a. Racks shall be UL Listed and of aluminum construction with a black polyurethane or mil finish. They shall be 84” tall with a 15” base depth. Rack base shall be pre-drilled for securing rack to the floor. Racks shall have 12/24 mounting screws included in the package.
- b. Rack rails shall be spaced for 19” mounting rail-to-rail and shall be of a U-shaped construction with 12/24 pre-tapped holes in the 310-D standard hole pattern providing 45 rack spaces on both the front and rear. Rails shall have a universal side-drilling pattern to allow racks to be bolted together or attachment of accessories. Racks shall be secured to the floor with anchor bolts.
- c. Vertical cable management channels shall be provided for each rack. Channels should allow for and facilitate orderly routing of distribution cables.
- d. Acceptable racks: Ortonics MM10,
 - i. Or approved equivalent.

2. Floor Mounted Free Standing 4 Post Racks

- a. Four post aluminum frames with standard rails
- b. 45 Rack Units
- c. Black
- d. Similar to Ortronics MM20
 - i. 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 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 perforated and 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 TIA 310 D. The cabinet shall feature three sets of rails, front, center, and rear. 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 utilize cage nuts. 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.
 - j. Ortronics OR-QC422442 or approved equal.
4. Remote Equipment Box
- a. Hubbell Rebox RE4X
5. All racks and cabinets shall be capable of supporting the weight and space of existing and proposed equipment. 30% growth capacity shall be provided in addition to detailed requirements.
6. Racks, cabinets and other termination equipment shall be properly secured to the floor with appropriate anchors and bonded to Telecommunications Grounding System.
7. PDU
- a. Provide (1) transient surge protection strip for each TR and per rack/cabinet in the TER and TRs.
 - b. Tripplite PDUMNV20LX
 - c. Or approved equal

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
 - i. or approved equivalent

Vertical Cable Management

- d. Vertical Cable management shall be provided for all racks. Provide 2 for each rack or cabinet.
- e. Cable management shall be – Ortronics DVMS706
- f. Or approved equivalent.

C. Electrical Protection for Telecommunications

1. Telecommunications Grounding Busbars

- a. Each rack/cabinet shall have a horizontal or vertical rack/cabinet grounding busbar and shall be bonded to the grounding system.
- b. The telecom grounding and bonding system shall be bonded to the main electrical ground for the facility.

2.4 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. Systimax
- B. Category 6 100-ohm UTP Voice, Data, Wireless and Security cables each have a distinctive color. Submit for approval from design team.
 - 1. Hubbell HC6RPExx
 - 2. Hubbell HC6RRxx
 - 3. Hubbell C6SOPBK
 - 4. Or approved equal from
 - a. Hitachi
 - b. Belden
 - c. Berk-Tek
 - d. Systimax
- C. RG-16 Coaxial Cable
 - 1. Quad Shield 75 Ohm
 - 2. Plenum rated

2.5 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
 - c. Hubbell

2.6 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. Systimax
 - 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 PCBLMGT Rear Cable Manager
 4. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systimax
 - 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. Systimax
 - d. Leviton
- D. Fiber Adaptor Panels
1. Hubbell FSPLCDM6AQ
 2. Hubbell FSPLCQM6AQ
 3. Hubbell FSPLCDS6
 4. Hubbell FSPLCQS3
 5. Or approved equal from
 - a. Ortronics

- b. Panduit
 - c. Systimax
 - d. Leviton
- E. Fiber Connector
 - 1. Hubbell FCLC900K50GM12 50/125um OM4 Aqua
 - 2. Hubbell FCLC900K50GM12 9/125 UPC
 - 3. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systimax
 - d. Leviton
- F. 110 Blocks
 - 1. Hubbell 110BLK50FTK5
 - 2. Hubbell 110BLK100FTK5
 - 3. Hubbell 110BLK300FTK5
 - 4. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systimax
 - d. Leviton

2.7 OUTLETS

- A. Category 6a Wireless Jacks
 - 1. Hubbell HJ6Axx (replace xx with specified colors)
 - 2. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systimax
 - 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. Systimax
 - d. Leviton
- C. Faceplates
 - 1. Grommeted Opening
 - 2. Brushed Opening
 - 3. Hubbell IFP11xx
 - 4. Hubbell IFP12xx
 - 5. Hubbell IFP13xx
 - 6. Hubbell IFP14xx
 - 7. Hubbell IFP16xx
 - 8. Hubbell IFP26xx
 - 9. Hubbell IFP29xx
 - 10. Hubbell IFP212xx
 - 11. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systimax

- 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. Systimax
 - d. Leviton

2.8 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. Systimax
 - 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. Systimax
 - d. Leviton
- C. Fiber Patch Cords
 - 1. Hitachi Singlemode
 - 2. Or approved equal from
 - a. Ortronics
 - b. Panduit
 - c. Systimax
 - d. Leviton

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 the 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 the 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. 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 TGB or appropriate building ground using a minimum #6 grounding wire.
- B. 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 as per BOCA.
4. Do not violate manufacturers' 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 distance 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. Contractors 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. The 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. Cables 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.
- C. Determine allowable cable proximity to other electrical power sources of 480 Volts or less using ANSI/TIA-569A "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 kV</u>	<u>> 5 kVA</u>
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	3 in.	6 in.	12 in.

non-metal pathways

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.

D. Interior 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.

E. Cable 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 manufacturers.
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 it 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, cables 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. A 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 bridge rings. No cables shall be installed on the roof or exterior of the building.
 7. Infrastructure 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 and requirements regarding bending radius and slack. All bends, offsets and fittings shall be appropriately sized to provide 30% capacity after installation.
- F. Install all cables 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. The contractor shall verify TMGB has been bonded to building ground before declaring completion.
- G. 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, faceplates, 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 the 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-Built
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. Contractor's 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 2-Year Installers warranty has been given to a school district Technology representative.
 - 7. Submit Manufacturers Extended Warranty Application.

END OF SECTION 271000

SECTION 272000 - NETWORK EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. LAN Electronics (Owner Furnished, Owner installed, OFOI)
- B. Wireless Electronics (Owner Furnished, Contractor installed, OFCI)
- C. Power Protection Equipment (Contractor Furnished, Contractor Installed, CFCl)

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. “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. “Telecom Room (TR)” refers to an enclosed space for housing telecommunications equipment, cable terminations, and cross-connects. The room is the recognized cross-connect between the backbone or trunk cabling and horizontal cabling.
- E. “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 systems found in the building.

1.3 SYSTEM DESCRIPTION

- A. Design Requirements
 - 1. Provide labor, materials, equipment, services and operations required for complete installation of LAN compatible with Ethernet 10Base-T (10Mbps), Fast Ethernet 100Base-T (100Mbps), 155Mbps ATM and Gigabit Ethernet 1000 Base-T (1000Mbps) with single mode fiber optic backbone cable and Category 6/6a copper horizontal (station) wiring.
 - 2. Chassis Switch in TER shall be connected to access switches located in Telecommunication Rooms (TR/IDF) by the fiber backbone. Access switches shall distribute data throughout the network over twisted-pair cable.
 - 3. Network devices must be able to accommodate 100% of network outlets, with at least 15% spare ports in aggregate for future use.
 - 4. Network equipment shall be capable of supporting, multiple Virtual Local Area Networks (VLAN), VoIP protocols, ATM protocols and Gigabit Ethernet.
 - 5. Permanently identify and label all cables and termination devices, at distribution rack and workstation in accordance with ANSI TIA-606-A Standard or as agreed by Design consultant and Authority.
- B. Performance Requirements

1. Comply with applicable requirements in Local, State and Federal Codes, ANSI/TIA Standards, and BICSI methodology. Industry Codes, Standards and Methods shall be observed by the contractor, including the following:
2. ANSI/TIA-568.0-E: Generic Telecommunications Cabling for Customer Premises
3. ANSI/TIA-568.1-E: Commercial Building Telecommunications Cabling Standard
4. ANSI/TIA-568.2-D: Balanced Twisted Pair Cabling and Components Standard
5. ANSI/TIA-568.3-D: Optical Fiber Cabling Components Standard
6. ANSI/TIA-569-E: Commercial Building Standard for Telecommunications Pathways and Spaces
7. ANSI/TIA-606-C: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
8. ANSI/TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
9. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Cabling Standard
10. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
11. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

1.4 SUBMITTALS

- A. Comply with the requirements of 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. Network Switch Equipment
 2. Patch Cables/Jumpers
 3. UPS Equipment
 4. Wireless Access Controller
 5. Wireless Access Points
- C. Shop Drawings
 1. The Contractor shall submit detailed line drawings of all systems showing major components of the systems. Submit wiring diagrams showing connections for all systems and equipment. Submittals will be rejected by the design consultant and owner without detailed line drawings.
 2. The shop drawings shall be submitted by the contractor in hardcopy and electronic format. Provide quantities called out in Division 1.
- D. Quality Control Submittal
 1. Test Reports: Submit complete sample test data and reports.
 2. Certificates

- a. Manufacturer Certification: Submit certification from the 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.”

E. As-Built Drawings and Test Results

1. Comply with requirements of Division 1, including submission of operating and maintenance instructions as item in “Operation and Maintenance Data” manual described in that Section.
2. Provide test results for all communications circuits installed, including UTP channel performance and fiber optic backbone cabling and terminations.
3. Accurate as-built drawings shall be provided by the contractor in electronic and hard copy format.
 - a. Drawings shall accurately show and describe all cable routing and equipment location in redline format.
 - i. Location of outlets and equipment on building floorplans
 - ii. Identification of labeling used for outlets and distribution racks
 - iii. Cable routing and pathways for telephone and LAN cabling.
 - b. 3 copies of electronic (CAD) drawings shall be distributed on appropriate media: 1 to construction management, 1 to designers and 1 to district technology staff.
 - 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.

1.5 QUALITY ASSURANCE

- A. All Work shall be installed in a first class, neat and skillful manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized district personnel. Any work found to be of inferior quality and/or workmanship shall be replaced by the contractor and/or reworked until the approval of district staff is obtained.
- B. Installer Qualifications: Certified by equipment manufacturer for installation of equipment. The instructor must be qualified at the appropriate level to validate equipment warranty.
- 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, the 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 the specified warranty.
7. If the proposed product involves more than one contractor, the 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 the 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

1. All manufacturer warranties shall be activated and passed on to Owner. Warranty shall commence from the time of substantial completion.

1.7 OPERATION AND MAINTENANCE MANUALS

1. All applicable materials shall be given to the owner during training in electronic and hardcopy format if available.
2. Any password or key for specific system shall be given to the owner as part of the operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

1. All networking switching electronics shall be based on Cisco Meraki – No Substitutions.
2. Catalog and part numbers must be from the most current vendor catalogs available at the time of installation.
3. Wireless Equipment shall be from Cisco Meraki – No Substitutions.

2.2 EQUIPMENT

A. Router (Owner Furnished, Owner Installed)

1. Cisco / Meraki

- a. Cisco 3850-24XS-E
- B. Access Layer Switches (Owner Furnished, Owner Installed)
 - 1. Fast Ethernet POE Stackable Switches and components
 - a. Cisco Meraki MS225-24P-HW
 - b. Cisco Meraki LIC-MS225-24P-10YR
 - c. Cisco Meraki MS225-48FP-HW
 - d. Cisco Meraki LIC MS225-48FP-10YR
 - e. Cisco Meraki MA-CBL-40G-50CM
 - f. Cisco Meraki MA-CBL-40G-1M
 - g. Cisco Meraki MA-CBL-40G-3M
 - h. Cisco Meraki MA-CBL-TA-3M
 - i. Cisco Meraki SFP-10G-LRM
 - j. Cisco Meraki MA-SFP-10GB-LRM
 - k. Cisco Meraki Single Mode LC-LC 3 Meter
 - l. Provide all with power supplies.
 - m. Provide all with stacking cables.
 - n. Provide all with 10 Gig Transceivers.
 - o. Refer to T-Drawings for quantities.
 - 2. Maintenance and Warranty
 - a. Per device
- C. Power Protection Equipment (Contractor Furnished, Contractor Installed)
 - 1. Preferred Alternate
 - a. APC
 - 2. Acceptable Substitutes
 - a. Tripplite
 - b. Eaton
 - 3. UPS Equipment
 - a. APC Smart-UPS SRT 2200 VA RM Network Card
 - b. Provide and install rack shelves for UPS equipment.

2.3 WIRELESS EQUIPMENT

- A. Exact quantity of wireless access points shall be determined by the wireless site survey at the time of installation.
- B. The wireless controller shall be sized appropriately based on the exact number of installed wireless access points.
- C. Wireless Controller (Owner Furnished, Contractor Installed)
 - 1. Meraki Cloud Management
- D. Wireless Access Point (Owner Furnished, Contractor Installed)
 - 1. Meraki MR44
 - a. With Access Point License.
 - b. With Grid Mount Kit
 - c. With Wall Mount Kit
 - 2. Meraki MR56 (Large Spaces, Gym Café)
 - a. With Access Point License.
 - b. With Grid Mount Kit
 - c. With Wall Mount Kit

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 consultants 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 the field and confirm the 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 the design consultant in writing of any discrepancies or issues in design described in Contract Documents.

3.2 INSTALLATION

A. Power Protection Equipment

1. UPS shall be mounted in equipment racks according to manufacturer's specifications and as shown on T-series drawings.
2. Coordinate the location of twist-lock electrical power with UPS equipment in all telecom rooms.
3. All network equipment in telecom rooms shall utilize UPS power, except as noted in T-series drawings or individual spec sections.
4. Provide sufficient battery capacity for equipment in individual telecom rooms.

B. Switching Electronics

1. The contractor shall securely mount switches in distribution racks as shown on T-series drawings.
2. Equipment shall utilize UPS power, through multi-outlet power strips.
3. The contractor shall verify and provide test results showing 100% functionality of switch ports.
4. Switches shall be interconnected using manufacturer recommended patch cords, transceivers and equipment cords.
5. Wireless Equipment
 - a. Contractor shall perform a wireless site survey to provide complete building coverage at a minimum of 1 Gb/sec in all locations.
 - b. Utilize W type drops located above the ceiling grid throughout the facility.
 - c. Wireless systems shall be completely operational and programmed through wireless controllers located in equipment racks.
6. Network Architecture
 - a. Contractors shall maximize singlemode cable between head end and telecom rooms, so that most switches are directly fed into core switches. When stacking is required due to limited availability of fiber, contractors shall verify in writing to Architect.
 - b. All PoE switches shall be connected through singlemode fiber optic cabling directly to core switch.
 - c. The contractor shall verify configuration of switches with School District personnel and reserve up to 16 hours to coordinate installation with School District employees.

C. Network Server

1. Servers shall be installed per manufacturers' specifications in the distribution rack in the Equipment Room.
2. Coordinate installation and configuration of server directly with School District employees.

3. Provide all patch and equipment cords necessary for full installation.

3.3 LABELING

- A. Permanently identify all system components following ANSI/TIA-606A “Administration Standard for Commercial Telecommunications Infrastructure” with identification format:
 1. Each individual patch cord shall be labeled on both ends regardless of cable intended use. Labels must be machine printed with permanent black ink on laminated white label material. Contractors must check with appropriate district personnel for appropriate labeling scheme. The intended format and labeling material must be approved by a district Technology Department before labeling begins.
 2. Equipment shall be given a unique identifier, corresponding to as-built drawings.
 3. Refer to T-Drawings for naming conventions.

3.4 TESTING

- A. 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.

3.5 ACCEPTANCE

- A. Contractor’s work shall be considered complete after the following conditions have been met:
 1. Network, Wireless and VoIP Equipment has been provided, installed and tested for functionality.
 2. Switching equipment has been demonstrated to allow a “ping” from any point on the LAN to equipment outside of LAN. The contractor shall coordinate with School District to schedule demonstration of network equipment.
 3. Patch cords have been properly installed. Any patch cords not employed in network shall be assembled and turned over to the School District.
 4. All punch list items have been reconciled.
 5. All disturbed ceiling panels, firestopping materials, covers, etc. have been properly reinstalled.
 6. All materials and trash have been removed from the site.
 7. Manufacturers’ Warranty Certificates and product materials have been given to the Owner.

END OF SECTION 272000

SECTION 27 40 00 - CLASSROOM AND CONFERENCE ROOM A/V EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Audio Visual Cabling Harness (Contractor Furnished, Contractor installed, CFCI)
2. Electronic Displays (Owner Furnished, Contractor Installed, OFCI)

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 switching and routing within the classroom. System must handle analog and digital sources.

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. Articles 250, 725, 760, 770, 800,810 and 820 of the current National Electrical Code.
 - b. ANSI/TIA-568.0-E: Generic Telecommunications Cabling for Customer Premises
 - c. ANSI/TIA-568.1-E: Commercial Building Telecommunications Cabling Standard
 - d. ANSI/TIA-568.2-D: Balanced Twisted Pair Cabling and Components Standard
 - e. ANSI/TIA-568.3-D: Optical Fiber Cabling Components Standard
 - f. ANSI/TIA-569-E: Commercial Building Standard for Telecommunications Pathways and Spaces

- g. ANSI/TIA-606-C: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
- h. ANSI/TIA-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
- 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. Product Data: Submit manufacturer's product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.
 - 1. Audio Visual cables and connectors
 - 2. Communications outlets, faceplates, and accessories.
 - 3. Wall outlets
- C. The Contractor shall submit line drawings of all systems showing major components of the systems. Submit wiring diagrams showing typical connections for all systems and equipment.
- D. 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."
- E. 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, 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 2 years from the 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. Liberty Cables
 2. Smart Technologies
 - a. Substitutions are not allowed.
 3. All Audio/Visual Cabling shall be from one manufacturer and have pre-terminated connectors.
- B. General Classroom/Conference Room A/V Cabling (Contractor Furnished, Contractor Installed)
1. AV Cabling
 - a. 6' HDMI cables
 - b. 6' USB (A-B) cables
 - c. Extron Plenum Pro with equalizer.
 - d. C2G USB 2.0 Superbooster External kit.
 - e. RJ-45 shielded modular ends.
 - f. Grommited / Brushed Opening white wall plates.
 - g. Decora wall plates white
 2. Cables in proper length to reach outlets.
 3. Provide each AV system with all cables on both ends of the system.
- C. Classroom Wall Mounted Electronic Displays (Contractor Furnished, Contractor Installed)
1. With embedded computing.
 2. 75" SMART Board Display (Provide at each M outlet)
 - a. Smart SBID-MX075-V4 Interactive Display
 - b. Provide associated WM-SBID-200 mount.
 3. 65" SMART Board Display (Provide four (4) mobile units)
 - a. Smart SBID-MX065-V4 Interactive Display
 - b. Provide associated FS-SBID-200 Mobile Stand
- D. Wall Mounted Electronic Displays (Contractor Furnished, Contractor Installed)
1. Samsung QM55B (Provide at Each V outlet)
 2. Include all mounts.

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 800.52. 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 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-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. 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-569A "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 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. Install all cables 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, 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. Audio Visual Harness

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-Built

A. Accurate as-built drawings shall be provided in electronic and hard copy format.

1. Drawings shall accurately show and describe all cable routing and equipment location in redline format.
2. 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.
3. Diagrams: The Contractor shall furnish three complete sets of operating instructions, including cable diagrams, and other information necessary for proper installation, operation and maintenance of the system components. As-built drawings of the system shall be supplied.

3.6 Acceptance

A. Contractor's 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, have been properly reinstalled.
5. All materials and trash have been removed from the site.
6. A 2-Year Installers warranty has been given to a school district Technology representative.

7. Submit Manufacturers Extended Warranty Application.

END OF SECTION 274000

SECTION 27 41 00 - SPECIALIZED A/V SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. This section and associated drawings define audio and video systems for the cafeteria spaces. The contractor shall provide all equipment, cables and components necessary for complete systems.
 - a. These systems shall be integrated with each other and function both separately and as a unit.

1.2 SYSTEM DESCRIPTION AND SUMMARY

A. Audio / Video Systems

1. Cafe AV multi-input, mixing and multi-loudspeaker system shall be provided. The equipment rack shall contain the audio and video equipment and allow for presets or live mixing if various inputs. Loudspeakers shall be provided and place as shown on the drawings. Large format displays which are capable of displaying a variety of sources shall be fully implemented and programmed for the owner's use. Clearly label and color code the master volume control for all functions. Wireless microphones and assistive listening devices shall be provided as part of the systems
2. All stand-alone sound systems must have call override from the Intercom/PA system in the case of an emergency.
3. Hearing Assistance System - Provide a reinforcement system for the hearing impaired in the Gymnasium and Cafeteria. 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.

B. 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. Digital and Analog Input Plates

- b. Scalers
- c. Processors
- d. Mixers
- e. Touch Panels
- f. Controllers
- g. Signal Extenders
- h. Switchers
- i. Display Devices
- j. Input Sources
- k. Sound coverage and pressure level diagram for each auxiliary sound system
- l. Sound Amplifier
- m. Sound Speakers
- n. Sound Microphones
- o. Sound Cabling and Wiring
- p. Audio Visual cables and connectors
- q. Communications outlets, faceplates, and accessories.
- r. Wall outlets
- s. Wire types
- t. System wiring diagrams showing all connections
- u. Shop Drawings including all equipment locations
- v. Associated equipment specifications and cut sheets

- w. 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 fully equipped service organization.
- 2. Submit a certificate of completion of installation and service training from the system manufacturer.
- 3. 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.”
 - 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 system personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of school system personnel 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 2 years from the 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.
 - 3. In addition, the primary manufacturer of the Networked Communications and Event Management System will offer a 5-year warranty on all items they supply.
- 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 contractors shall provide a minimum of two hardcopy and one electronic copy of all operation and maintenance manuals to the owner at project completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable manufacturers
 - 1. The auxiliary sound systems are based on Biamp, Shure, Extron, Listen, Crown, Lowell and other 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.

2.2 MATERIALS

- A. PRODUCT OVERVIEW.

2.3 Auxiliary Sound Systems

- A. Cafeteria Sound and Video Equipment
 - 1. AV Mixer
 - a. Extron IN1608 xi
 - 2. Controller
 - a. Extron IPCP Pro S6
 - 3. Keypad Controller
 - a. Extron TLP Pro 525 M
 - 4. Mixer / DSP
 - a. Biamp TesiraFORTE DAN AI
 - 5. Input Plates
 - a. BTX Custom Plates
 - b. RDL DD-BTN44
 - 6. Amplifier
 - a. Crown CDi 1000
 - b. Crown XLC 12300
 - c. QSC 1450HDa
 - 7. CD/Bluetooth Player
 - a. Denon DN-BD500

8. AV Switch
 - a. 12 Port PoE+ Gigabit managed Switch
9. Loudspeakers
 - a. JBL CBT1000 +CBT1000E
 - b. Community V2-215S
10. Mounting Bracket
 - a. Per Speaker type
 - b. Adjustable.
11. Stage Monitor
 - a. EVI ZX1 (2)
12. Hearing Assistance System
 - a. Listen LS-54-72 (2)
13. Equipment Cabinet
 - a. Middle Atlantic floor cabinet (SR-46-48)
 - b. Swing open
 - c. Vented Front door
14. Rack Shelf
 - a. Middle Atlantic D3LK
15. Hinged Panel Mount
 - a. Middle Atlantic HPM-4
16. Lid
 - a. Middle Atlantic HPM-LID
17. 25' Mic Cables
 - a. ProCo SMM25 (4)
18. 50' Mic Cables
 - a. ProCo SMM50 (2)
19. 25' Patch Cable
 - a. ProCo S12NN-25 (2)
20. 24 VDC Power Supply
 - a. As needed

21. Wireless Mics
 - a. ULXS24/58 (2)
22. Boundary Mic
 - a. Shure MX391/C (3)
23. Handheld Mic
 - a. Shure SM58 (4)
24. Gooseneck Task Light
 - a. Soundcraft LittleLite (1)
25. Mic Stands
 - a. Ultimate MC-05B (6)
26. MP3 Input
 - a. Whirlwind Isopod (1)
27. DI Box
 - a. Whirlwind IMP2 (2)
28. Direct Box
 - a. Whirlwind PCDI (1)
29. Power Sequencer
 - a. SurgeX SEQ 2RU
30. Signal Extenders
 - a. Extron DTP HDMI Series
31. Projector
 - a. Epson L1070UNL with ELPLM11 lens appropriate for throw and screen size.
 - i. Adjust as needed based on field conditions.
 - ii. Coordinate installation with architecture. Install in recessed projector alcove.
 - iii. If necessary due to architecture, provide ceiling plate, adjustable pipe, universal
32. Screen
 - a. By Div 11
 - b. Coordinate in the field with exact screen chosen.
33. Cables
 - a. HDMI

- b. VGA
 - c. 3.5 MM
 - d. Extron XTP Cables
- B. Café B Sound Equipment:
- 1. Controller
 - a. Biamp TEC-1s
 - 2. AV Switch
 - a. 8 Port PoE Gigabit Switch
 - 3. Mixer / DSP
 - a. Biamp TesiraFORTE DAN AI
 - b. Include all required cards
 - 4. XLR Input Plates
 - a. BTX Custom as needed
 - b. RDL DD-BTN44
 - 5. Amplifier
 - a. QSC RMx 1450a
 - 6. Loudspeakers
 - a. EV SX100+
 - b. Mount to structure and also include safety rigging.
 - 7. Mounting Bracket
 - a. EV MB
 - 8. Shunt Relay
 - a. Bogen VAR1
 - 9. Controller
 - a. Crestron MC4 with ANT-EXT-10 Antenna and MTX-3 Remote
 - 10. Hearing Assistance
 - a. Listen LS-54-072 Kit
 - 11. Equipment Rack
 - a. Lowell LWBR-4028
 - 12. Door

- a. Lowell LFD-40FV
- 13. Rack Shelf
 - a. Lowell US-214
- 14. Blank Panel
 - a. Lowell LE-193
- 15. Storage Drawer
 - a. Lowell UDP-414 (1)
- 16. Line Level
 - a. RDL STACR-2 (1)
- 17. Power Supply
 - a. RDL PS-24AS (2)
- 18. Line Level Transformer
 - a. RDL TX-70A (1)
- 19. CD/Bluetooth Player
 - a. Tascam CD-200BT
- 20. Wireless Mics
 - a. Shure ULXS24/58 (2)
- 21. Antenna
 - a. Shure UA844SWB (2)
- 22. Handheld Mic
 - a. Shure SM58 (2)
- 23. 25' Mic Cable
 - a. ProCo SMM25 (2)
- 24. Mic Stands
 - a. Ultimate MC-05B (2)
- 25. MPC Input
 - a. Whirlwind Isopod
- 26. Direct box
 - a. Whirlwind PCDI (1)
- 27. Power Sequencer
 - a. SurgeX SEQ

28. Cables

- a. 18/2 AWG Speaker Wire
- b. XLR Mic Cables
- c. Cat 6 UTP

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 bridle 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 TIA/EIA-568.B 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. All cabling must be within conduits/raceways or above false ceilings. Exposed cables are not acceptable and the system will be rejected if cabling is visible.
- D. 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 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.
- F. Properly terminate all cables at speakers, call switches, administrative consoles and distribution racks. Permanently identify all cables in pull boxes, transition points, and termination points by affixing pre-marked self-adhesive wraps similar to Brady “B-500+ Plastic Cloth Markers.”
- G. 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. Audio Visual Equipment

- 1. The contractor shall test all equipment 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.

B. Sound Equipment

- 1. The contractor shall test all aspects of the sound system once it is installed and demonstrate these functions to the owner of the owner’s representative.
 - a. Speaker levels shall be verified to function individually and as a unit
 - b. Microphones shall be demonstrated to work as intended by the manufacturer.

3.5 Acceptance

- A. Contractor’s 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. All materials and trash have been removed from the site.
 - 6. A 2-Year Installers warranty has been given to a school district Technology representative.

7. Submit Manufacturer's Warranty Application.

END OF SECTION 274100

SECTION 27 50 00 - PUBLIC ADDRESS AND CLOCK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. This section and associated drawings define a communications system for a public address. The contractor shall provide all infrastructure, cable, hardware and equipment as defined to provide a complete and operational system.

1.2 SYSTEM DESCRIPTION AND SUMMARY

- A. Furnish and install all equipment, accessories, and materials in accordance with the specifications herein and drawings to provide a complete and operating Networked Communications and Event Management System.

B. 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. Wire types
 - b. System wiring diagrams showing all equipment and connections.
 - c. Drawings including all equipment locations.
 - d. Associated equipment specifications and cut sheets.
 - e. 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 fully equipped service organization.
2. Submit a certificate of completion of installation and service training from the system manufacturer.
3. 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.”
- 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 AutoCAD 2015 and hardcopy format that clearly show all system components, wiring schemes and interconnections.
- 1. PDFs inserted into CAD files are not acceptable and will be rejected.

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 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. 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 2-years 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.
 - 3. In addition, the primary manufacturer of the Networked Communications and Event Management System will offer a 5-year warranty on all items they supply.

1.7 Training

- A. The installing contractor shall provide a minimum of 8 hours of training on system operation and management 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 contractors shall provide a minimum of two hard copies and one electronic copy of all operation and maintenance manuals to the owner at project completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable manufacturers
 1. The preferred Alternate shall be Bogen.
 - a. Substitutions must provide equal or greater performance. Any other manufacturers will be rejected at the contractor's expense.
 - b. The functions and features specified are vital to the operation of this facility and therefore all requirements of the system must be met by the specified equipment.

2.2 MATERIALS

- A. PRODUCT OVERVIEW.
 1. PA and Clock System and Equipment
 2. Supply and install a complete microprocessor based Public Address system for bell schedule. The preferred alternate system shall be a Bogen.
 - a. Any substitute shall provide equal or greater performance.
 - b. Telecor
 - c. Rauland
 - d. Valcom
- B. CENTRAL Equipment
 1. UPS
 - a. APC 2200 VAC UPS with 5-20r plug.
 2. Web Interface
 - a. Bogen Nyquist UI
 3. Equipment Cabinet
 - a. Bogen 84" floor mounted cabinet

4. System Controller
 - a. Bogen NQ-SYSCTRL
5. 4 Channel Matrix Mixer
 - a. Bogen NQ-P0100
6. Input/Output Controller
 - a. Bogen NQ-E7010
7. Admin Phone
 - a. Bogen NQ-T1100
8. Zone Paging Mic Station
 - a. NQ-ZPMS
9. Plenum Amplifier
 - a. Bogen NQ-GA20P2
10. Plenum Rated Amplifier Module
 - a. Bogen NQ-GA40P3
11. VoIP Ceiling Speakers
 - a. Bogen NQ-S1810CT-G2
 - b. Bogen NQ-S1810CT-T1
12. 4-Channel Amplifiers
 - a. Bogen NQ-A4300-G2
13. VoIP Wall Speaker
 - a. Bogen S1810WT-G3
14. Analog Speakers:
 - a. Drop-in Ceiling Speakers: CSD2X2VR/U Drop-In Ceiling Speakers
 - b. Cut-in Ceiling Speakers: S86T725PG8U
 - c. Wall Speakers: MB8TSQ/SL Metal Box Speakers
15. Outdoor / Gym / Locker Room Speakers shall be Atlas Sound:
 - a. Atlas Sound VTF-157UCN or similar
16. Pendant Speaker:
 - a. Tannoy OCV 6
 - b. TOA PE-304

- c. TOA PJ-304
- 17. Volume Controller
 - a. Bogen AT-10
- 18. Call Station with integrated speaker
 - a. Bogen Nyquist NQ-EDP01
- 19. Media Player
 - a. Denon DN-700CB
- 20. Microphone
 - a. Bogen MBS1000A
- 21. Phone System Integration
 - a. The system allows access to live paging and emergency event initiation through telephone access, as well as through the web-browser User Interface. Dial up (through a PBX, PSTN or IP Based VoIP System) allows users who do not have immediate access to a web browser to access critical communication functionality during an emergency. This feature will allow user specific, pin code protected access to the system live paging, and emergency event initiation for each user's unique programmed locations. This requires a separate server to interface to the Networked Communications and Event System server and the district phone system.
- C. CLOCK SYSTEM
 - 1. Sapling
- D. CLOCKS
 - 1. 12" Analog Battery Powered Clocks
- E. SPARE CAPACITY/SYSTEM EXPANSION
 - 1. The contractor shall include extra circuits for staff telephones and loudspeakers built into the system for future expansion. The contractor shall provide and install fifteen percent (25%) 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.
- F. REMOTE SOUND SYSTEMS INTERLOCK
 - 1. Provide circuits, as required, to include loudspeakers connected to remote (local) sound systems into the telecommunication system. Remote loudspeakers shall be temporarily "seized" during paging, two-way intercom, any transmitted tone-sets and program distribution, which include the remote system(s) area(s). After completion of the transmission the remote sound system shall be returned to normal local operation.
- G. Cable and Jacks
 - 1. Cat 6 UTP

2. 18/2 AWG plenum rated cable
 - a. Increase cable gauge as needed.
3. 18/4 AWG plenum rated cable
 - a. Increase cable gauge as needed.
4. PA Cable must be presented to the architect/engineer and owner for approval prior to installation.

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 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 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 bridle 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. 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 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.
- D. Install all cables 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. 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 pull boxes, 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 ANSI/TIA-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. PA and Clock Equipment
 - 1. The contractor shall test all equipment 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.
- B. Sound Equipment
 - 1. The contractor shall test all aspects of the sound system 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. Microphones shall be demonstrated to work as intended by the manufacturer.

3.5 Programming

- A. All aspects of the system shall be fully programmed and active for the owner.
- B. Integration with local sound systems shall be programmed.
- C. Integration with owner telephone equipment shall be programmed.
 - 1. The system shall work seamlessly with owner supplied telephone equipment allowing calls to be answered and initiated with telephone equipment through the system.
 - 2. Coordinate all programming with the owner and owner’s equipment at the time of construction and installation.

3.6 As-builts

- A. As-builts shall be provided by the contractor in hardcopy and electronic CAD format prior to project completion and inspection. PDFs inserted into CAD documents are not acceptable.
- 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.

3.7 Demonstration and Training

- A. All aspects of the systems must be demonstrated for the owner at the time of training. A minimum of 16 hours of training shall be provided.
- B. Training shall be video and audio recorder for the owner and turned over to the owner at acceptance.

3.8 Acceptance

- A. Contractor's 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. All materials and trash have been removed from the site.
 - 6. A 2-Year Installers warranty has been given to a school district Technology representative.
 - 7. Submit Manufacturer's Warranty Application.

END OF SECTION 275000

SECTION 28 20 00 - VIDEO SURVEILLANCE SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Video Surveillance Cabling, Cameras, NVRs, Control Equipment, Cabling and interface units.
- B. Associated power supplies, terminations, labeling and associated cable performance testing.
- C. All materials, terminations, equipment, labeling and associated cable performance testing.

1.2 Definitions

- A. Refer to sections 27 and 28 for applicable definitions and terms.
- B. CCTV and video surveillance refer to the same system and are used interchangeably. Terms refer to cabling system included in this specification section.

1.3 System Description

A. Design Requirements

- 1. Provide labor, materials, equipment, services and operations required for complete installation of a CCTV System.
 - a. Fiber/PoE extenders and associated power wiring shall be homerun from end device location to head equipment location without breaks or splices.
 - b. Cat 6 UTP network cables with all terminations from cameras to switches and control equipment shall be installed without splicing.
 - c. Cables shall be routed from distribution racks throughout the building as shown 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. Strictly adhere to most current versions of ANSI/TIA Telecommunications cabling standards.
 - d. 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 Authority.
 - e. Remove and replace any cables failing to meet end-to-end testing requirements; do not abandon cables in place. All cables shall be terminated at both ends, unless noted in T-Drawings.

B. CCTV System Requirements

- 1. The system shall provide notification of events occurring on the system.
- 2. The system shall be on emergency power systems.

3. The system shall be on the local area network.
4. The system shall integrate with other currently installed systems within the district.
5. The system shall be field-controllable and programmable.
6. The system shall allow access restrictions.
7. The contractor shall be responsible for form, fit, function, and coordination of all part numbers listed above, and bring to owner's attention any changes or substitutions for approval.
8. No surface metal raceway shall be used unless approved by the owner, and if approved, shall be painted to match adjacent wall color.

C. 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-C.0: Generic Telecommunications Cabling for Customer Premises.
 - b. ANSI/TIA-568-C.1: Commercial Building Telecommunications Cabling Standard
 - c. ANSI/TIA-568-C.2: Balanced Twisted Pair Cabling and Components Standard
 - d. ANSI/TIA-568-C.3: Optical Fiber Cabling Components Standard
 - e. ANSI/TIA-569-B: Commercial Building Standard for Telecommunications Pathways and Spaces
 - f. ANSI/TIA-570-B: Residential Telecommunications Cabling Standard
 - g. ANSI/TIA-606-A: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
 - h. ANSI-J-STD-607-D: Commercial Building Grounding and Bonding Requirements for Telecommunications
 - i. ANSI/TIA-758-A: Customer-Owned Outside Plant Telecommunications Cabling Standard
 - j. BICSI Telecommunications Distribution Methods Manual (TDMM), Latest Edition
 - k. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

1.4 Submittals

- A. Comply with the 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. Video Management System (VMS)
 - 2. Video Recorder Units (NVRs)
 - 3. Cameras
 - 4. Fiber and PoE extenders
 - 5. Copper cable, patch cables and termination devices
 - 6. Video Surveillance Control Software
 - 7. Video Surveillance Control Servers
 - 8. Inner duct and accessories
 - 9. Complete Wiring diagrams
 - 10. Sample of each cable test report.
- C. Shop Drawings: Provide complete shop drawings showing all devices, device connections, wiring pathways, wire types, headend equipment elevations and associated components prior to installation, for approval by designer.
 - 1. Shop drawings shall be submitted in AutoCad and PDF format.
- D. Quality Control Submittal
 - 1. Test Reports: Submit complete sample test data and reports with exact labels used on cables and patch panels.
 - 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."
- E. 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 skillful manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized owner personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of the owner is obtained.
- B. Qualifications
 - 1. Installer

- a. Qualified to cable, terminate and test data network cabling system, coaxial cable system and associated power wiring specified in this Section and section 271000, 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, the 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 the specified warranty.
 7. If the 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 the 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 2 years from the date of final acceptance.
- B. A fifteen (15) year Extended Product Warranty and Systems Assurance Warranty for UTP camera wiring system shall be provided by the Manufacturer as follows:
 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.

- C. Manufacturer warranty coverage for coaxial cable systems associated with the CCTV System.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Video Surveillance Equipment (No substitutions)
 - 1. Milestone VMS
 - 2. Milestone NVRs
 - 3. Cisco Meraki Switching Equipment (Owner Furnished, Owner Installed)
 - 4. Axis Cameras (Basis of Design)
 - a. Acceptable Substitutes
 - i. Avigilon
 - ii. Vicon
 - iii. Hanwha
 - b. Cameras must be listed as compatible partner products on the Milestone website.
- B. 4-Post Equipment Rack
 - 1. Floor mounted 4-Post Equipment Rack.
 - 2. See Section 270500 / 271000 for details.
- C. UPS Equipment
 - 1. UPS Equipment
 - a. APC Smart-UPS SRT 2200 VA RM Network Card
 - b. Provide and install rack shelves for UPS equipment.
- D. Cabling Components for video surveillance systems.
 - 1. UTP Camera Cabling (Plenum Rated)
 - a. CCTV System cabling shall be a distinct color.
 - b. Camera cabling shall provide identical performance to Cat 6 UTP data and voice cabling included in Section 27 10 00 and meet all district performance criteria.
 - c. Third-party verified to meet ANSI/TIA Category 6 requirements. All completed cabling channels are fully backwards compatible with the requirements of Category 5 and 5e cabling systems.
 - d. See section 27 10 00 for cabling requirements.
 - 2. Patch Panels for CCTV Cabling

- a. All patch panels must provide identical performance to Cat 6 patch panels included in Section 27 10 00 and meet all district performance criteria.
 - b. Shall meet requirements for category 6 (per SCHOOL DISTRICT standards) performance requirements.
 - c. Panels shall contain the number of termination ports required to terminate all LAN and telephone jacks in the service area, plus 20% spare capacity.
 - d. Acceptable units:
 - e. See section 27 10 00.
 - f. Panels shall contain the number of termination ports required to terminate all LAN and telephone jacks in the service area, plus 20% spare capacity.
3. Patch Cables for CCTV Cabling
 - a. Factory terminated and tested UTP patch cables at workstation and equipment cross-connect meeting requirements of ANSI/TIA-568-B for patch cable testing.
- E. Video Management System
 1. Milestone Xprotect.
- F. Video Surveillance NVRs / Servers
 1. Milestone Husky IVO
 - a. 75% Recording in a 24-Hour time period, minimum of 15 FPS at full camera resolutions.
- G. CCTV Cameras
 1. Interior cameras shall be an Axis P3267-LVE 5 MP dome ceiling/wall mount color units.
 2. Exterior units shall be an Axis P3267-LVE 5 MP pendant and dome with associated mounts.
 3. 180° Cameras shall be Axis P3818-PVE 13 MP Network Camera dome with associated mounts.
 4. 360° Cameras shall be Axis P3737-PLE 4X2 MP Network Cameras dome with associated mounts.
- H. Pole Enclosure
 1. Altronix WP3 with a pole mount kit.
- I. The owner shall provide the system with static IP addresses as needed for multiplexers, and remote master viewing station (PCs) access. Contractor shall supply the Owner with a minimum of (4) copies of software.
- J. The Owner shall supply remote viewing station PCs.
- K. Provide ceiling or wall mount bracket to support flat screen LCD TVs/all-in-one PCs as indicated on drawings. These TVs shall be fed network cabling.

L. CCTV Wiring

1. Leviton One Reach system (for site cameras) over 95 meters
2. Singlemode Fiber
3. Cat 6 UTP
4. 18/2 AWG

PART 3 - EXECUTION

3.1 Examination

- A. Verification of Conditions: Examine conditions under which CCTV 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 the 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 the installer.
 2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.
 3. Verify all dimensions in the field and confirm the 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 the 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 circuits and/or 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 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 LAN, Horizontal, Homerun multi conductor cable or coaxial video distribution cable is prohibited.
 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 as per BOCA.
 4. Do not violate manufacturers' 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 distance 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. Install cables in EMT in all unfinished, exposed areas as shown in Design consultant and Architectural roof plans and/or T-Drawings, unless alternate pathways are noted.
 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. Provide a minimum of 15' of cable slack at camera location and 10 feet at patch panels, unless noted otherwise. Do not coil cable slack
 10. Place cables in compliance with ANSI/TIA-568.C standards and BICSI recommended methods.
 11. 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.
 12. 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.
 13. Cable bundles shall be secured using only black Velcro cable wraps.
 14. 10 feet of service slack shall be provided in the ceiling at each device location. Contractors shall not secure service loop in coils, but route in such a manner as to minimize EMI.
- B. 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.
- C. Install all cables 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. Properly terminate all cables at camera locations 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."
- E. Permanently identify all system components following ANSI/TIA 606 "Administration Standard for Commercial Telecommunications Infrastructure" with identification format:
 1. Identification: Provide permanent identification labels for patch panels, access panels and entrance facilities.

3.4 Testing

A. Video Surveillance System

1. Upon completion of work, all parts of the telecommunications installation shall be tested by the low voltage 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 using proper test equipment for the system to be 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.
3. All aspects of the management and control system shall be tested and shown to operate as specified by the manufacturer.

3.5 As-Builts

A. Accurate as-built drawings shall be provided in electronic and hard copy format.

1. 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.
2. 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.

B. As-builts shall accurately show all devices, wiring, control equipment, rack elevations, equipment elevations and system interconnections.

3.6 Demonstration

A. Video Systems Demonstration

1. 8 Hours of demonstration and training on all aspects of the completely installed systems must be provided for the owner.
 - a. Training shall be video recorded for the owner and given to them after acceptance.
 - b. Training and system demonstrations must include all aspects of the system and its operation.

- c. Additional training, beyond the initial 8 hours, shall be provided for the owner at their request on an hourly rate basis.

3.7 Acceptance

- A. The 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 aspects of the system have been shown to operate as per manufacturer's specifications.
 - 3. A school district security representative has successfully tested the "LIVE" system.
 - 4. All punch list items have been reconciled by the contractor.
 - 5. All disturbed ceiling panels, covers, etc. have been properly reinstalled.
 - 6. All materials and trash have been removed by the contractor from the site.
 - 7. A 2-Year Installers warranty has been given by the contractor to a school district Security representative.
 - 8. Submit Manufacturers Extended Warranty Application.

END OF SECTION 282000

SECTION 311000 - SITE CLEARING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- 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. Removing existing trees, shrubs, groundcover, plants, and grass.
 - 2. Clearing and grubbing.
 - 3. Stripping and stockpiling topsoil.
 - 4. Removing above- and below-grade site improvements.
 - 5. Replacing any damaged site features not indicated to be removed (i.e. fencing, walks, landscaping, etc.)
 - 6. Temporary erosion and sedimentation control measures.
- B. Related Sections include the following:
 - 1. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.
 - 2. Division 32 Section "Turf and Grasses" for finish grading including preparing and placing planting soil mixes and testing of topsoil material.

1.3 DEFINITIONS

- A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.
- B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.4 MATERIAL OWNERSHIP

- A. For ownership of cleared materials, Contractor shall coordinate with Construction Manager scope of work. Except for stripped topsoil that can be reused on site or other materials indicated

to remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 SUBMITTALS (NOT USED)

1.6 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without written permission from the Owner.
 - 2. Provide alternate routes around closed or obstructed traffic ways.
- B. Utility Locator Service: Notify Miss Utility a minimum of 3 days prior to performing any land disturbing activities. Contact Miss Utility of Delmarva 1-800-282-8555
- C. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.

PART 2 - PRODUCTS (Not Applicable)

2.1 SOIL MATERIALS

- A. Satisfactory Soil Materials: Requirements for satisfactory soil materials are specified in Division 2 Section "Earthwork."
 - 1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Locate and clearly flag trees and vegetation to remain or to be relocated.
- C. Protect existing site improvements to remain from damage during construction.
 - 1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TREE PROTECTION

- A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.
 - 1. Do not store construction materials, debris, or excavated material within fenced area.
 - 2. Do not permit vehicles, equipment, or foot traffic within fenced area.
 - 3. Maintain fenced area free of weeds and trash.
- B. Do not excavate within tree protection zones, unless otherwise indicated.
- C. Where excavation for new construction is required within tree protection zones, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.
 - 1. Cover exposed roots with burlap and water regularly.
 - 2. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
 - 3. Coat cut faces of roots more than 1-1/2 inches in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
 - 4. Backfill with soil as soon as possible.
- D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.
 - 1. Replace trees that cannot be repaired and restored to full-growth status, as determined by Architect.

3.3 UTILITIES

- A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.
 - 1. Arrange with utility companies to shut off indicated utilities.
 - 2. Owner will arrange to shut off indicated utilities when requested by Contractor.
- B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify the Owner not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without the University's written permission.
- C. Excavate for and remove underground utilities indicated to be removed.
- D. Removal of underground utilities is included in Division 2 Sections covering site utilities.

3.4 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction.
 - 1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
 - 2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
 - 3. Grind stumps and remove roots, obstructions, and debris extending to a depth of 24 inches below exposed subgrade.
 - 4. Use only hand methods for grubbing within tree protection zone.
 - 5. Chip removed tree branches and dispose of off-site.
- B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
 - 1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.5 TOPSOIL STRIPPING

- A. Remove grass before stripping topsoil.
- B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials. Contactor may refer to Geotechnical Report for more detailed site conditions.
 - 1. Remove subsoil and non-soil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.
- C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Do not stockpile topsoil within tree protection zones.
 - 2. Dispose of excess topsoil as specified for waste material disposal.
 - 3. Stockpile surplus topsoil to allow for re-spreading deeper topsoil.

3.6 SITE IMPROVEMENTS

- A. Replace any existing site improvements damaged during construction operations, not indicated to be removed (i.e. fencing, walks, landscaping, utilities, sanitary and storm structures, etc.)
- B. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.
- C. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.7 DISPOSAL

- A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.
 1. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

END OF SECTION 311000

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SECTION 312000 – EARTH MOVING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:

1. Preparing subgrades for pavements, walkways, pads, and slabs on grade.
2. Excavating and backfilling for retaining walls and structures.
3. Subbase course for concrete walks.
4. Subbase course for asphalt paving.
5. Subsurface drainage backfill for walls and trenches.
6. Excavating and backfilling for utility trenches.
7. Excavating and backfilling trenches for buried mechanical and electrical utilities and pits for buried utility structures.

- B. Related Sections include the following:

1. Division 31 Section *Site Clearing* for, site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
2. Division 32 Section *Erosion and Sediment Control*, for temporary erosion and sediment control.
3. Division 32 Section *Turf and Grasses* for finish grading, including preparing and placing topsoil and planting soil for lawns.

1.03 DEFINITIONS

- A. Backfill: Soil materials used to fill an excavation, including the backfill of retaining walls, footings and foundations.
 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Course placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Course placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill. See section 2.1 for the requirements of borrow soil.

- E. Drainage Course: Course supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
 - 1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect.
 - 2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.
- G. Fill: Soil materials used to raise existing grades.
- H. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material 3/4 cu. yd. or more in volume that exceed a standard penetration resistance of 100 blows/2 inches when tested by an independent geotechnical testing agency, according to ASTM D 1586.
- I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- J. Subbase Course: Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- K. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.
- L. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.04 SUBMITTALS

- A. Comply with Division 1 Section *Submittal Procedures*.
- B. For Approval
 - 1. Product Data: For the following:
 - a. Geotextile support fabric.
 - b. Geotextile filter fabric.
- C. For Information:
 - 1. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
 - a. Classification according to ASTM D 2487 of each on-site and borrow soil material proposed for fill and backfill.
 - b. Laboratory compaction curve according to ASTM D 698 for each on-site and borrow soil material proposed for fill and backfill.

1.05 PROJECT/ SITE CONDITIONS

- A. Test borings and other exploratory operations may be made by the Contractor at no cost to the Owner.
- B. Existing Utilities: Locate existing underground utilities by hand excavation in areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations.
 - 1. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner. Do not break utility connections without providing temporary services, as acceptable to Engineer.
 - 2. Do not interrupt existing utilities serving facilities occupied and used by Owner or others, during occupied hours, except when permitted in writing by Engineer and then only after acceptable temporary utility services have been provided.
 - a. Provide, to Architect, a minimum of 48 hour notice to proceed before interrupting any utility.
 - 3. Demolish and completely remove from site any existing underground utilities indicated to be removed. Coordinate with utility companies for shut-off of services if lines are active.
- C. Use of Explosives: The use of explosives is not permitted.
- D. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights.
 - 1. Operate warning lights as recommended by authorities having jurisdiction.
 - 2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

1.06 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with applicable regulatory requirements of municipality and utility companies.
- B. Under pavements, prepared subgrade must be proof rolled to a visually firm and stable condition and to a minimum of 95 percent maximum dry density as determined by a standard proctor test (ASTM: D698) with a minimum 10-ton smooth-wheeled roller in presence of a qualified Geotechnical Engineer or Technician prior to the placing of any base material.
- C. A qualified Geotechnical Engineer or Technician, paid for by the Owner, shall monitor all site preparing, grading, and fill construction. The Engineer/Technician should observe and document the site preparation, existing fill material removal, and fill/backfill construction work, and make appropriate field tests, as necessary, to verify that acceptable fill materials are being used and that construction is being performed in accordance with applicable plans, specifications and acceptable construction practices.

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations. **Note: No warranty is made regarding the amount of on site soils material suitable for use as fill or backfill of any kind.** Contractor is required for removal of unsuitable excavated materials and importing of suitable soils for backfill.
- B. Satisfactory Soils: Satisfactory soils for use as fill are defined below:
1. Structural fill, Fill under building slabs on grade and foundations, drives and parking, and behind retaining walls (where applicable): Where available, on site soil materials may be used where these on site soils conform to the requirements of the Delaware Department of Transportation Type C– Select borrow. Where sufficient on site soils materials are not available, off site borrow conforming to the requirements of the Delaware Department of Transportation Type C – select borrow shall be provided.
 2. Fill under walkways: Where available, on site soil materials may be used where these on site soils conform to the requirements of the Delaware Department of Transportation Type C – select borrow. When sufficient on-site soils materials are not available, off site borrow conforming to the requirements of the Delaware Department of Transportation Type C – select borrow shall be provided.
 3. Fill under unimproved, grass or landscape areas: Any on site soil material free of organic material and rocks or clumps larger than 2 inches.
- C. Backfill:
1. Backfill for all utility trenches under asphalt, walkway areas: may be on site material where these on site soils conform to the requirements of the Delaware Department of Transportation Type C – Select borrow. When sufficient on-site soils materials are not available, off site borrow conforming to the requirements of the Delaware Department of Transportation Type C – select borrow shall be provided.
 2. Backfill for all utility trenches under unimproved, grass areas: Any on site soil material free of organic material and rocks or clumps larger than 2 inches.
- D. Fill: All fill shall be comprised of satisfactory soil material as defined above, section 2.01.B.
- E. Subbase: Shall be Delaware Department of Transportation Type A CR-1 graded aggregate, DelDOT specification section 821.03.
- F. Bedding: Shall be Delaware Dept. of Transportation #57 stone.
- G. Drainage Fill Course: Shall be Delaware Dept. of Transportation #57 stone.

2.02 GEOTEXTILES

- A. Geotextile Filter Fabric: Nonwoven geotextile, specifically manufactured as a drainage and separation geotextile; made from polypropylene staple fibers; and with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
 - 1. Grab Tensile Strength: 120 lb; ASTM D 4632
 - 2. Tear Strength: 60 lb; ASTM D4533
 - 3. Puncture Resistance: 70 lb; ASTM D 4833.
 - 4. Water Flow Rate: 135 gpm per sq. ft.: ASTM D 4491
 - 5. Apparent Opening Size: No. 70; ASTM D 4751
- B. Geotextile Support Fabric: Woven geotextiles, specifically manufactured for use as a support and separation geotextiles, comprised of UV stabilized polypropylene slit film; and with the following minimum properties according to ASTM D 4759 and referenced standard test methods:
 - 1. Grab Tensile Strength: 315 lb; ASTM D 4632.
 - 2. Tear Strength: 120 lb; ASTM D 4533.
 - 3. Puncture Resistance: 120 lb; ASTM D 4833.
 - 4. Apparent Opening Size: No. 40; ASTM D 4751.

2.03 GEOGRID REINFORCEMENT

- A. For use in unsuitable soil areas, as directed by the Architect, shall be an integrally formed grid structure manufactured of a stress resistant polypropylene material. The geogrid shall accept applied force in use by positive mechanical interlock with compacted soil or construction fill materials. The geogrid shall possess sufficient flexural stiffness to enable efficient installation over weak or wet in situ soils and shall possess complete continuity of its properties throughout its structure. Geogrid soil reinforcement shall be Tensar BX1100 geogrid, or approved equal.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Division 2 Section "Site Clearing."
- C. Protect and maintain erosion and sedimentation controls, which are specified in Division 2 Section "Site Clearing," during earthwork operations.
- D. Provide protective insulating materials to protect subgrades and foundation soils against freezing temperatures or frost.

3.02 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area. The bidder is responsible for

complete dewatering for all site work including stormwater management and erosion control facilities. All dewatering methods must be approved by DNREC and must be per the DNREC ESC Handbook, latest revision effective July 1, 2005. The bidder should thoroughly familiarize themselves with existing on-site soils and groundwater conditions and review the Geotechnical Report. **With the exception of DNREC Well-Pointing (if applicable), contractor is responsible as part of the base bid contract scope of work to provide all required dewatering for all excavation & construction activities (utilities, storm, tie-in to pond, structures, etc.). Dewatering must be performed per DNREC specifications (i.e. pump through dirt bag with stone pit).**

- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
 - 2. Install a dewatering system to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.

3.03 EXPLOSIVES

- A. Explosives: Do not use explosives.

3.04 SITE STRIPPING AND PREPARATION IN STRUCTURAL AREAS

- A. At the start of construction all existing topsoil, roots, asphalt and existing fill material should be stripped and removed in their entirety from the proposed building, parking, and drive areas extending to a minimum lateral distance of 10' beyond outer edge of paved areas and 15' beyond outside edge of building footings. Any existing fill material that may be encountered in previously disturbed areas (e.g., utility trenches), as well as any existing utility lines, should also be removed in their entirety from the building area. Contactor may refer to Geotechnical Report for more detailed site conditions.
- B. After completing removal of the above, and upon reaching grade (in cut areas) and/or subgrade (in fill areas), the entire area should be proof-rolled with a minimum 10-ton smooth-wheeled roller or other approved equipment. The purpose of the proof-rolling is to densify the exposed grade/subgrade areas, which have been loosened or disturbed during the stripping/grading operation. In addition, the proof-rolling will expose any localized soft areas not encountered during the test boring program. In subgrade areas to receive structural fill, the exposed subgrade areas should be compacted to a visually firm and stable condition; compacted subgrade must be inspected and approved by the Geotechnical Engineer. This subgrade compaction effort will enable any structural fill to be placed and compacted at the required densities. Any localized soft and/or excessively wet subgrade areas encountered during this program, which cannot be adequately stabilized by drying and compacting, should be undercut and replaced with properly compacted structural fill (DelDOT Type G) or other suitable materials as directed by Geotechnical Engineer.

3.05 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil

materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.06 EXCAVATION FOR RETAINING WALLS AND OTHER STRUCTURES (if applicable)

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.

3.07 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.08 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit.
 1. Clearance: 12 inches each side of pipe or conduit.
- C. Trench Bottoms: Excavate trenches deeper than bottom of pipe elevation to allow for bedding course (bedding course thickness and material shall be as specified on the drawings and/or specs and as recommended by manufacturer). Hand excavate for bell of pipe.

3.09 SUBGRADE INSPECTION

- A. Notify Architect/Geotechnical Engineer when excavations have reached required subgrade.
- B. If Geotechnical Engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below pavements, walkways and structures with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated, or frozen subgrades.
 1. Completely proof-roll subgrade in one direction.
 2. Proof-roll with a minimum 10 ton vibratory roller or a fully loaded tandem dump truck in the presence of a qualified soils technician.

3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Geotechnical Engineer, and replace with compacted backfill or fill as directed.

- D. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, dust/drought conditions, or construction activities, as directed by Geotechnical Engineer.

3.10 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.11 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, foundations and retaining walls.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

- B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.

- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

- C. Place and compact initial backfill, material as defined in section 2.01.C to a height of 12 inches over the utility pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

- D. Place and compact final backfill of material specified in section 2.01.C to final subgrade elevation.

3.13 STRUCTURAL LOAD BEARING FILL/BACKFILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

- B. The load bearing fill material should be placed in horizontal thin lifts with a loose thickness no greater than 8 inches. For top 1-foot of pavement and slab subgrades, each thin lift of fill material should be compacted to 100% maximum dry density, as determined by the Standard Proctor Test (ASTM D-698). For fills below 1 foot of pavement subgrade and for structural fill below building slab and footings/foundations, each thin lift of fill material should be compacted to 95% maximum dry density, as determined by the Standard Proctor Test (ASTM D-698). Structural fill placement, as defined above, shall extend to a minimum lateral distance of 10' beyond outer edge of paved areas and 15' beyond outside edge of building footings.
- C. Place soil material on subgrades free of mud, frost, snow, ice, or other deleterious materials.

3.14 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
 - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace, or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698:
 - 1. Under structures, building slabs, steps, and fills below 1-foot of pavement subgrade, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.
 - 2. For top 1-foot of pavement and slab subgrades, each thin lift of fill material should be compacted to 100% maximum dry density.
 - 3. Under walkways, scarify and recompact top 6 inches (below subgrade and compact each layer of backfill or fill soil material at 95 percent.
 - 4. Under lawn or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 85 percent.
 - 5. For utility trenches, compact each layer of backfill soil material at 95 percent.

3.16 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
 - 1. Provide a smooth transition between adjacent existing grades and new grades.

2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

- B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Lawn or Unpaved Areas: Plus or minus 1 inch.
2. Walks: Plus or minus 1 inch.
3. Pavements: Plus or minus 1/2 inch.

3.17 SUBBASE AND BASE COURSES

- A. Place subbase and base course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase and base course under pavements, courts, and walks as follows:
1. Where shown on the plans, install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 2. Shape subbase course to required crown elevations and cross-slope grades.
 3. Place subbase course 6 inches or less in compacted thickness in a single layer.
 4. Place subbase course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
 5. Compact subbase course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.18 FIELD QUALITY CONTROL

- A. Testing Agency: Owner shall engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.
- B. Testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work complies with requirements.
- C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.
- D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
1. Paved Areas, Building Slabs, and Areas beneath athletic courts: At subgrade and at each compacted fill and backfill layer, at least 1 test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than 3 tests.
 2. Structural Fill and Backfill: At each compacted backfill layer, at least 1 test for each 2000 square feet, but no fewer than 3 tests.

3. Trench Backfill: At each compacted initial and final backfill layer, at least 1 test for each 150 feet or less of trench length, but no fewer than 2 tests.

- E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

3.19 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.20 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property to DNREC approved location.

END OF SECTION 312000

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SECTION 321216 - ASPHALT PAVING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary and other Conditions, if any) and Division 1 as appropriate, apply to the Work specified in this Section.

1.02 SECTION INCLUDES

- A. Refer to Scope Information Sheets for this contract bound in the Project Manual. The Scope Information Sheets describe generally the work included in each contract, but the work is not necessarily limited to that described.
- B. Provisions for hot-mixed asphalt paving over prepared subbase.
- C. Proof rolling of prepared sub base.
- D. Traffic Paint
- E. Contractor shall coordinate all construction documents related to work specified herein; where conflicts arise between these specifications and the design drawings, the more stringent shall apply. The Contractor is advised to contact the Architect with any questions prior to resolving any conflicts, or modifying any of the original design.

1.03 RELATED SECTIONS

- A. Prepared subbase is specified in another Division 31, Section “Earth Moving”.
- B. Saw-cutting of edges of existing pavement is specified in site-clearing section.

1.04 SUBMITTALS

- A. Material Certificates signed by material producer and Contractor, certifying that each material item complies with or exceeds specified requirements.

1.05 PROJECT/SITE CONDITIONS

- A. Weather Limitations: Apply prime and tack coats when ambient temperature is above 50 deg F (10 deg C) and when temperature has not been below 35 deg F (1 deg C) for 12 hours immediately prior to application. Do not apply when base is wet or contains an excess of moisture.
- B. Construct hot-mixed asphalt surface course when atmospheric temperature is above 40 deg F (4 deg C) and when base is dry. Base course may be placed when air temperature is above 30 deg F (minus 1 deg C) and rising.

- C. Grade Control: Establish and maintain required lines and elevations.

1.06 MATERIALS

- A. General: Use locally available materials and gradations that exhibit a satisfactory record of previous installations.
- B. Coarse Aggregate: Sound, angular crushed stone, crushed gravel, or properly cured crushed blast furnace slag, complying with ASTM D 692-88.
- C. Fine Aggregate: Sharp-edged natural sand or sand prepared from stone, properly cured blast furnace slag, gravel, or combinations thereof, complying with ASTM D 1073.
- D. Asphalt Cement: ASTM D 3381 for viscosity-graded material; ASTM D 946 for penetration-graded material.
- E. Prime Coat: Cut-back asphalt type, ASTM D 2027; MC-30, MC-70 or MC-250.
- F. Tack Coat: Emulsified asphalt; ASTM D 977.
- G. Subbase Reinforcement Fabric. Structural Geogrid BX 1200

1.07 ASPHALT-AGGREGATE MIXTURE

- A. Provide plant-mixed, hot-laid asphalt-aggregate mixture complying with ASTM D 3515 and applicable Delaware Department of Transportation standards.

1.08 TRAFFIC PAINT

- A. Traffic Paint: Apply traffic paint for striping and other markings with mechanical equipment to produce uniform straight edges. Apply at manufacturer's recommended rates to provide a 15-mil minimum wet film thickness. All traffic striping is to conform to Delaware Department of Transportation standard specifications.

PART 2 - EXECUTION

2.01 SURFACE PREPARATION

- A. General: Remove loose material from compacted subbase surface immediately before applying prime coat.
- B. Proof-roll prepared subbase surface to check for unstable areas and areas requiring additional compaction.
- C. Notify Engineer of unsatisfactory conditions. Do not begin paving work until deficient subbase areas have been corrected and are ready to receive paving.
- D. Prime Coat: Apply at rate of 0.20 to 0.50 gal. per sq. yd., over compacted subgrade. Apply material to penetrate and seal, but not flood, surface. Cure and dry as long as necessary to attain penetration and evaporation of volatile.

- E. Tack Coat: Apply to contact surfaces of previously constructed asphalt or Portland cement concrete and surfaces abutting or projecting into hot-mixed asphalt pavement. Distribute at rate of 0.05 to 0.15 gal. per sq. yd. of surface.
- F. Allow to dry until at proper condition to receive paving.
- G. Exercise care in applying bituminous materials to avoid smearing of adjoining concrete surfaces. Remove and clean damaged surfaces.

2.02 PLACING MIX

- A. General: Place hot-mixed asphalt mixture on prepared surface, spread, and strike off. Spread mixture at minimum temperature of 225 deg F (107 deg C). Place areas inaccessible to equipment by hand. Place each course to required grade, cross-section, and compacted thickness.
- B. Paver Placing: Place in strips not less than 10 feet wide, unless otherwise acceptable to Engineer. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete the base course for a section before placing surface course.
- C. Immediately correct surface irregularities in finish course behind paver. Remove excess material forming high spots with shovel or lute.
- D. Joints: Make joints between old and new pavements, or between successive days' work, to ensure continuous bond between adjoining work. Construct joints to have same texture, density, and smoothness as other sections of hot-mixed asphalt course. Clean contact surfaces and apply tack coat.

2.03 ROLLING

- A. General: Begin rolling when mixture will bear roller weight without excessive displacement.
- B. Compact mixture with hot hand tampers or vibrating plate compactors in areas inaccessible to rollers.
- C. Breakdown Rolling: Accomplish breakdown or initial rolling immediately following rolling of joints and outside edge. Check surface after breakdown rolling and repair displaced areas by loosening and filling, if required, with hot material.
- D. Second Rolling: Follow breakdown rolling as soon as possible, while mixture is hot. Continue second rolling until mixture has been evenly compacted.
- E. Finish Rolling: Perform finish rolling while mixture is still warm enough for removal of roller marks. Continue rolling until roller marks are eliminated and course has attained 95 percent laboratory density.
- F. Patching: Remove and replace paving areas mixed with foreign materials and defective areas. Cut out such areas and fill with fresh, hot-mixed asphalt. Compact by rolling to specified surface density and smoothness.

- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

2.04 FIELD QUALITY CONTROL

- A. General: Test in-place hot-mix asphalt courses for compliance with requirements for thickness and surface smoothness. Repair or remove and replace unacceptable paving as directed by Engineer.
- B. Thickness: In-place compacted thickness tested in accordance with ASTM D 3549 will not be acceptable if exceeding following allowable variations:
 - 1. Base Course: Plus or minus ½ inch.
 - 2. Surface Course: Plus or minus 1/4 inch.
- C. Surface Smoothness: Test finished surface of each hot-mixed asphalt course for smoothness, using 10-foot straightedge applied parallel with and at right angles to centerline of paved area. Surfaces will not be acceptable if exceeding the following tolerances for smoothness:
 - 1. Base Course Surface: 1/4 inch.
 - 2. Wearing Course Surface: 3/16 inch.
- D. Check surface areas at intervals as directed by Engineer.

END OF SECTION 321216

SECTION 321313 – CONCRETE PAVING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary and other Conditions, if any) and Division 1 as appropriate, apply to the Work specified in this Section.

1.02 SECTION INCLUDES

- A. Refer to Scope Information Sheets for this contract bound in the Project Manual. The Scope Information Sheets describe generally the work included in each contract, but the work is not necessarily limited to that described.
- B. Concrete steps, pads, curbs, and landings.

1.03 RELATED DOCUMENTS

- A. The Delaware Department of Transportation Standard Specifications for Road and Bridge Construction is hereby incorporated into this section and all requirements set forth there, shall be adhered to.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Section 312000 - "Earth Moving" for subgrade preparation, grading and subbase course outside the building area.
- C. The Contractor shall coordinate all construction documents related to work specified herein; where conflicts arise between these specifications and the design drawings, the more stringent shall apply. The Contractor is advised to contact the Architect with any questions prior to resolving any conflicts, or modifying any of the original design.

1.04 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for proprietary materials and items, including reinforcement and forming accessories, admixtures, joint systems, curing compounds, dry-shake finish materials, and others if requested by Architect.
- C. Design mixes for each class of concrete. Include revised mix proportions when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
- D. Laboratory test reports for evaluation of concrete materials and mix design tests.

- E. Material certificates in lieu of material laboratory test reports when permitted by Architect. Material certificates shall be signed by the manufacturer and the Contractor certifying that each material item complies with or exceeds requirements. Provide certification from admixture manufacturers that chloride content complies with requirements.

1.05 QUALITY ASSURANCE

- A. Concrete Standards: Comply with provisions of the following standards, except where more stringent requirements are indicated.
 - 1. American Concrete Institute (ACI) 301, “Specifications for Structural Concrete for Buildings.”
 - 2. ACI 318, “Building Code Requirements for Reinforced Concrete.”
 - 3. Concrete Reinforcing Steel Institute (CRSI) “Manual of Standard Practice.”
 - 4. Delaware Department of Transportation Standard Specifications.
- B. Concrete Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
- C. Concrete Testing Service: Engage a qualified independent testing agency to perform materials evaluation tests and to design concrete mixes.
- D. Seal all concrete surfaces with concrete sealer conforming to ASTM C309.

PART 2 - PRODUCTS

2.01 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other acceptable panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
 - 1. Use flexible or curved forms for curves of a 100-foot or less radius.

2.02 REINFORCING MATERIALS

- A. Reinforcing Bars and Tie Bars: ASTM A 615, Grade 60, deformed.
- B. Welded Steel Wire Fabric: ASTM A 185.
 - 1. Furnish in flat sheets, not rolls, unless otherwise acceptable to Architect.
- C. Deformed-Steel Welded Wire Fabric: ASTM A 497.
- D. Fabricated Bar Mats: Welded or clip-assembled steel bar mats, ASTM A 184. Use ASTM A 615, Grade 60 steel bars, unless otherwise indicated.
- E. Joint Dowel Bars: Plain steel bars, ASTM A 615, Grade 60. Cut bars true to length with ends square and free of burrs.

- F. Supports for Reinforcement: Chairs, spacers, dowel bar supports and other devices for spacing, supporting, and fastening reinforcing bars, welded wire fabric, and dowels in place. Use wire bar-type supports complying with CRSI specifications.
 - 1. Use supports with sand plates or horizontal runners where base material will not support chair legs.

2.03 CONCRETE MATERIALS

- A. Concrete materials to be used in project shall comply fully with the requirements of the DelDOT Standard specifications.
- B. Portland Cement: ASTM C 150, Type I.
 - 1. Use one brand of cement throughout Project unless otherwise acceptable to Architect.
- C. Fly Ash: ASTM C 618, Type F.
- D. Normal-Weight Aggregates: ASTM C 33, Class 4, and as follows. Provide aggregates from a single source.
 - 1. Maximum Aggregate Size: 1-1/2 inches.
 - 2. Do not use fine or coarse aggregates that contain substances that cause spalling.
 - 3. Local aggregates not complying with ASTM C 33 that have been shown to produce concrete of adequate strength and durability by special tests or actual service may be used when acceptable to Architect.
- E. Water: Potable.

2.04 ADMIXTURES

- A. Provide concrete admixtures that contain not more than 0.1 percent chloride ions.
- B. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures.
- C. Water-Reducing Admixture: ASTM C 494, Type A.

2.05 CURING MATERIALS

- A. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 2.
- B. Moisture-Retaining Cover: One of the following, complying with ASTM C 171.
 - 1. Waterproof paper.
 - 2. Polyethylene film.
 - 3. White burlap-polyethylene sheet.

2.06 CONCRETE MIX

- A. Prepare design mixes for each type and strength of normal-weight concrete by either laboratory trial batch or field experience methods as specified in ACI 301. For the trial batch method, use a qualified independent testing agency for preparing and reporting proposed mix designs.
 - 1. Do not use the Owner's field quality-control testing agency as the independent testing agency.
 - 2. Limit use of fly ash to 25 percent of cement content by weight.
- B. Proportion mixes according to ACI 211.1 and ACI 301 to provide normal-weight concrete with the following properties:
 - 1. Compressive Strength (28-Day): 4000 psi.
 - 2. Compressive Strength (28-Day): 3500 psi.
 - 3. Maximum Water-Cement Ratio at Point of Placement: 0.45.
 - 4. Slump Limit at Point of Placement: 3 inches.
- C. Adjustment to Concrete Mixes: Mix design adjustments may be requested by the Contractor when characteristics of materials, project conditions, weather, test results, or other circumstances warrant.

2.07 CONCRETE MIXING

- A. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94.
 - 1. When air temperature is between 85 deg F (30 deg C) and 90 deg F (32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.01 SURFACE PREPARATION

- A. Proof-roll prepared subbase surface to check for unstable areas and verify need for additional compaction. Do not begin paving work until such conditions have been corrected and are ready to receive paving.
- B. Remove loose material from compacted subbase surface immediately before placing concrete.

3.02 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for paving to required lines, grades, and elevations. Install forms to allow continuous progress of work and so that forms can remain in place at least 24 hours after concrete placement.
- B. Check completed formwork and screeds for grade and alignment to following tolerances:
 - 1. Top of Forms: Not more than 1/8 inch in 10 feet.
 - 2. Vertical Face on Longitudinal Axis: Not more than 1/4 inch in 10 feet.

- C. Clean forms after each use and coat with form release agent as required to ensure separation from concrete without damage.

3.03 PLACING REINFORCEMENT

- A. General: Comply with Delaware Department of Transportation Standard Specifications for placing reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
- D. Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces at least one full mesh and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
- E. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities or replace units as required before placement. Set mats for a minimum 2-inch overlap to adjacent mats.

3.04 JOINTS

- A. General: Construct contraction, construction, and isolation joints true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to the centerline, unless indicated otherwise.
 - 1. When joining existing paving, place transverse joints to align with previously placed joints, unless indicated otherwise.
- B. Contraction Joints: Provide weakened-plane contraction joints, sectioning concrete into areas as shown on Drawings. Construct contraction joints for a depth equal to at least 1/4 of the concrete thickness, as follows:
 - 1. Tooled Joints: Form contraction joints in fresh concrete by grooving and finishing each edge of joint with a radiused jointer tool.
 - 2. Inserts: Form contraction joints by inserting premolded plastic, hardboard, or fiberboard strips into fresh concrete until top surface of strip is flush with paving surface. Radius each joint edge with a jointer tool. Carefully remove strips or caps of two-piece assemblies after concrete has hardened. Clean groove of loose debris.
- C. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than ½ hour, unless paving terminates at isolation joints.
 - 1. Provide preformed galvanized steel or plastic keyway-section forms or bulkhead forms with keys, unless indicated otherwise. Embed keys at least 1-1/2 inches into concrete.
 - 2. Continue reinforcement across construction joints unless indicated otherwise. Do not continue reinforcement through sides of strip paving unless indicated.
 - 3. Provide tie bars at sides of paving strips where indicated.
 - 4. Use bonding agent on existing concrete surfaces that will be joined with fresh concrete.

3.05 CONCRETE PLACEMENT

- A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.
- B. Remove snow, ice, or frost from subbase surface and reinforcing before placing concrete. Do not place concrete on surfaces that are frozen.
- C. Moisten subbase to provide a uniform dampened condition at the time concrete is placed. Do not place concrete around manholes or other structures until they are at the required finish elevation and alignment.
- D. Comply with requirements of the Delaware Department of Transportation for measuring, mixing, transporting, and placing concrete.
- E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- F. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- G. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures to consolidate concrete complying with ACI 309R.
 - 1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand-spreading and consolidation. Consolidate with care to prevent dislocating reinforcing, dowels, and joint devices.
- H. Screed paved surfaces with a straightedge and strike off. Use bull floats or darbies to form a smooth surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces prior to beginning finishing operations.
- I. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not acceptable, remove and replace with formed concrete.
- J. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.
- K. Cold-Weather Placement: Comply with provisions of ACI 306R and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 - 1. When air temperature has fallen to or is expected to fall below 40 deg F (4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture

- temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.
2. Do not use frozen materials or materials containing ice or snow.
 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise accepted in mix designs.
- L. Hot-Weather Placement: Place concrete complying with ACI 305R and as specified when hot weather conditions exist.
1. Cool ingredients before mixing to maintain concrete temperature at time of placement to below 90 deg F (32 deg C). Mixing water may be chilled or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedding in concrete.
 3. Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.06 CONCRETE FINISHING

- A. Float Finish: Begin floating when bleed water sheen has disappeared and the concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand-floating if area is small or inaccessible to power units. Finish surfaces to true planes within a tolerance of 1/4 inch in 10 feet as determined by a 10-foot-long straightedge placed anywhere on the surface in any direction. Cut down high spots and fill low spots. Refloat surface immediately to a uniform granular texture.
1. Broom Finish: Brush across concrete, perpendicular to line of traffic, to provide a uniform finish.
- B. Final Tooling: Tool edges of paving, gutters, curbs, and joints formed in fresh concrete with a jointing tool to radii as shown on the plans. Repeat tooling of edges and joints after applying surface finishes. Eliminate tool marks on concrete surfaces.

3.07 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with the recommendations of ACI 306R for cold weather protection and ACI 305R for hot weather protection during curing.
- B. Evaporation Control: In hot, dry, and windy weather, protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply according to manufacturer's instructions after screeding and bull floating, but before floating.
- C. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- D. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:

1. Moisture Curing: Keep surfaces continuously moist for not less than 7 days with the following materials:
 - a. Water.
 - b. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with a 12-inch lap over adjacent absorptive covers.
2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

3.08 TRAFFIC PAINT

- A. Traffic Paint: Apply traffic paint for striping and other markings with mechanical equipment to produce uniform straight edges. Apply at manufacturer's recommended rates to provide a 15-mil minimum wet film thickness. All traffic striping is to conform, at a minimum, to the design drawings.

3.09 FIELD QUALITY CONTROL TESTING

- A. Employ a qualified independent testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement as follows:
 1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
 - a. Slump: ASTM C 143; one test at point of placement for each compressive-strength test but no less than one test for each day's pour of each type of concrete. Additional tests will be required when concrete consistency changes.
 - b. Air Content: ASTM C 231, pressure method; one test for each compressive-strength test but no less than one test for each day's pour of each type of air-entrained concrete.
 - c. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F (4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each set of compressive-strength specimens.
 - d. Compression Test Specimens: ASTM C 31; one set of four standard cylinders for each compressive-strength test, unless directed otherwise. Mold and store cylinders for laboratory-cured test specimens except when field-cured test specimens are required.
 - e. Compressive-Strength Tests: ASTM C 39; one set for each day's pour of each concrete class exceeding 5 cu. yd. but less than 25 cu. yd., plus one set for each additional 50 cu. yd. Test one specimen at 7 days, test two specimens at 28 days, and retain one specimen in reserve for later testing if required.
 2. When total quantity of a given class of concrete is less than 50 cu. yd., Architect may waive strength testing if adequate evidence of satisfactory strength is provided.
 3. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.

4. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength and no individual strength test result falls below specified compressive strength by more than 500 psi.
- B. Test results will be reported in writing to Architect, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive strength tests shall contain the Project identification name and number, date of concrete placement, name of concrete testing agency, concrete type and class, location of concrete batch in paving, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-day and 28-day tests.

3.10 REPAIRS AND PROTECTION

- A. Remove and replace concrete paving that is broken, damaged, or defective, or does not meet the requirements of this Section.
- B. Drill test cores where directed by Architect when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with Portland cement concrete bonded to paving with epoxy adhesive.
- C. Protect concrete from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep concrete paving not more than two days prior to date scheduled for Substantial Completion inspections.

END OF SECTION 321313

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SECTION 322210 - EROSION AND SEDIMENT CONTROL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

Drawings and general provisions of contract, including General and Supplementary Conditions and Division 1 and 2 Specification sections apply to work of this section.

B. State of Delaware Sediment and Stormwater Regulations, latest edition.

C. State of Delaware Erosion and Sediment Control Handbook, latest revision.

1.2 SUMMARY

A. This Section includes the following:

1. Temporary erosion control devices required during construction.

B. Related Sections include the following:

1. Division 31 Section *Site Clearing* for site stripping, grubbing, stripping, and stockpiling topsoil and removal of above and below ground improvements.
2. Division 31 Section *Earth Moving* for excavation, grading, fill placement, and backfill of excavations with specified materials.

1.3 DEFINITIONS (NOT USED)

1.4 SUBMITTALS

A. Comply with Division 1 Section *Submittal Procedures*

B. For Approval:

1. Product Data: For the following:
 - a. Inlet Filter Protection and pre-fabricated silt fence.
 - b. Geotextile Fabrics
 - c. Erosion Control Matting (SC 150 BN)

C. For Information:

1. Materials test report: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
 - a. Classification according to ASTM of all stone and aggregate for use in erosion control devices such as stabilized construction entrances, rock check dams, and silt fence.

1.5 QUALITY ASSURANCE

- A. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.

- B. General Intent: In accordance with State of Delaware, Section 1, Title 7, Delaware Code Chapter 40 "Erosion and Sediment Control Act," erosion and sediment control will be minimized during construction of the project by temporary and/or permanent stabilization by seeding and other controls to limit erosion. All erosion and sediment controls shall be constructed and installed as detailed on drawings and as per DNREC's Delaware Erosion & Sediment Control Handbook, Latest revision. As part of the base bid contract scope of work Contractor is responsible for installing additional Erosion & Sediment Control (ESC) measures as directed by Certified Construction Reviewer CCR and/or Engineer as construction progresses. The actual ESC measures shown on the plan are the minimum required to start work and install the proposed site improvements. As construction progresses additional ESC items may be required (i.e. dewatering bag, stone check dams, silt tubes, etc.) to comply with the State Sediment and Stormwater Regulations; these ESC items must be installed as directed by CCR and/or Engineer at no additional cost to owner. Contractor is also responsible for maintaining all ESC measures throughout duration of construction including re-seeding disturbed areas and repairing ESC items as directed by CCR and Engineer.
- C. Contractor is responsible for providing all required CCR Services and As-Built Services as specified on the Contract Documents and as required by DNREC.

1.6 PROJECT CONDITIONS (NOT USED)

PART 2 - PRODUCTS

- 2.1 SILT FENCE (must conform to DNREC ESC Handbook Standards, Latest revision):
- 2.2 STABILIZED CONSTRUCTION ENTRANCE (must conform to DNREC ESC Handbook Standards, Latest revision)
 - A. Stone: Use 2" stone or recycled concrete equivalent
 - B. Filter Fabric: Woven or non-woven fabric consisting only of continuous chain polymeric filaments or yarns of polyester. The fabric shall be inert to commonly encountered chemicals and hydrocarbons, and be mildew and rot resistant. Fabric shall be Trevira Spunbond 1135, Mirafi 600X or approved equivalent.

PART 3 - EXECUTION

- 3.1 INSTALL EROSION CONTROL MEASURES in accordance with the latest issue of Delaware Erosion Control Handbook (effective Latest revision) and as shown on drawings.
- 3.2 SILT FENCE: Install in accordance with the latest issue of Delaware Erosion Control Handbook (effective Latest revision) and as shown on drawings. Maximum allowable slope length shall be per Delaware Erosion Control Handbook Standards and specifications for silt fence.
 - A. Filter cloth to be fastened securely to fence posts with wire ties or staples.

1. Stake size, installation, spacing, and fabric overlap shall conform to the DNREC ESC Handbook details and specifications.
- B. Maintenance shall be performed as needed and material removed when “bulges” develop in the silt fence.

3.3 STABILIZED CONSTRUCTION ENTRANCE:

- A. Length: As required, but not less than 50 feet.
- B. Thickness: Not less than 6 inches.
- C. Width: 10 foot minimum, but not less than the full width at points where ingress or egress occurs.
- D. Surface Water: All surface water flowing or diverted toward construction entrances shall be piped across the entrance. If piping is impractical, a mountable berm with 5:1 slopes will be permitted.
- E. Maintenance: The entrance shall be maintained in a condition, which will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional stone as conditions demand and repair and/or cleanout of any measures used to trap sediment. All sediment spilled, dropped, washed or tracked onto public rights-of-way must be removed immediately.
- F. Washing: Vehicle wheels shall be cleaned to remove sediment prior to entrance onto public rights -of-way. When washing is required, it shall be done on an area stabilized with stone and which drains into an approved sediment-trapping device.

END OF SECTION 322210

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SECTION 332510 WATER DISTRIBUTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- 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 water-distribution piping and specialties outside the building for the following:
 - 1. Combined water service and fire-service mains.

1.3 DEFINITIONS

- A. Combined Water Service and Fire-Service Main: Exterior water piping for both domestic-water and fire-suppression piping.
- B. Fire-Service Main: Exterior fire-suppression-water piping.
- C. Fire-Suppression-Water Piping: Interior fire-suppression-water piping.
- D. Water-Distribution Piping: Interior domestic-water piping.
- E. Water Service: Exterior domestic-water piping.
- F. The following are industry abbreviations for piping materials:
 - 1. DIP: Ductile Iron Pipe.
 - 2. PVC: Polyvinyl Chloride

1.4 SUBMITTALS

- A. For approval:
 - 1. Pipe and Fittings.
 - 2. Gate Valves and accessories.
 - 3. Tapping Sleeves and Valves.
 - 4. Fire Hydrants.

1.5 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of piping and specialties and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- B. Regulatory Requirements:

1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

C. Piping materials shall bear label, stamp, or other markings of specified testing agency.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:

1. Ensure that valves are dry and internally protected against rust and corrosion.
2. Protect valves against damage to threaded ends and flange faces.
3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

E. Protect stored piping from moisture and dirt. Elevate above grade.

F. Protect flanges, fittings, and specialties from moisture and dirt.

1.7 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Construction Manager and Owner not less than seven days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Construction Manager's and Owner's written permission.

1.8 COORDINATION

A. Coordinate connection to water supply with Construction Manager.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the products specified.
 2. Products: Subject to compliance with requirements, provide one of the products specified.
 3. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
 4. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 DUCTILE-IRON PIPE AND FITTINGS

- A. Mechanical-Joint, Ductile-Iron Pipe: Class 52, with mechanical-joint, bell- and plain-spigot end.
1. Mechanical-Joint, Ductile-Iron Fittings: Class 52, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - a. Glands, Gaskets, and Bolts: Class 52, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- B. Push-on-Joint, Ductile-Iron Pipe: Class 52, with push-on-joint, bell- and plain-spigot end unless grooved or flanged ends are indicated.
1. Push-on-Joint, Ductile-Iron Fittings: Class 52, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - a. Gaskets: Class 52, rubber.

2.4 GATE VALVES

- A. AWWA, Cast-Iron Gate Valves:
1. Manufacturers:
 - a. American Cast Iron Pipe Co.; American Flow Control Div.
 - b. American Cast Iron Pipe Co.; Waterous Co. Subsidiary.
 - c. Mueller Co.; Water Products Div.

- d. McWane, Inc.; Clow Valve Co. Div.
 - e. McWane, Inc.; Kennedy Valve Div.
 - f. McWane, Inc.; Tyler Pipe; Utilities Div.
 - g. NIBCO INC.
 - h. United States Pipe and Foundry Company.
- 2. Non-rising Stem Gate Valves 3 Inches (80 mm) and Larger: AWWA C509, resilient seated; bronze stem, iron body and bonnet with epoxy coated interior surfaces, iron disc with epoxy coating and replaceable steel reinforced rubber seat, double O-Ring seal stuffing box, 2" operating nut, open left, 200-psig (1380 kPa) working pressure, mechanical joint ends. Mueller A-2370-20, open left or approved equal.
 - 3. Valve Boxes: Cast-iron box having top section and cover with lettering "WATER," bottom section with base of size to fit over valve and barrel approximately 5 inches (124 mm) in diameter, and adjustable cast-iron extension of length required for depth of bury of valve. Mueller Type H10360, or approved equal.
 - 4. Provide one steel tee-handle operating wrench. Wrench shall have tee handle with one pointed end, stem of length to operate deepest valve, and socket-fitting valve-operating nut.

2.5 GATE VALVE ACCESSORIES AND SPECIALTIES

- A. Tapping-Sleeve Assemblies: Comply with MSS SP-60. Include sleeve and valve compatible with drilling machine.

- 1. Manufacturers:
 - a. American Cast Iron Pipe Co.; Waterous Co. Subsidiary.
 - b. Mueller Co.; Water Products Div.
 - c. International Piping Services Company.
 - d. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).
 - e. McWane, Inc.; Kennedy Valve Div.
 - f. McWane, Inc.; M & H Valve Company Div.
 - g. United States Pipe and Foundry Company.
- 2. Tapping Sleeve: Tapping sleeves shall be a Mueller mechanical joint tapping sleeve model H-615, or approved equal. The sleeve shall be a 2 piece bolted sleeve with flanged outlet for new branch connection. The outlet flange dimensions and drilling shall comply with ANSI B16.1, class 125. Sleeve shall be iron body with 3/4" NPT test plug and shall have a maximum working pressure of 200 psig.
- 3. Tapping Valve: Tapping valves shall be a Mueller Double Disc tapping valve model H-667, or approved equal. The valve shall meet or exceed all applicable requirements of ANSI/AWWA C500 standards. The inlet flange shall comply with ANSI B16.1, class 125 drilling, the mechanical joint outlet shall comply with ANSI/AWWA C111 Standards. The valve shall have a bronze mounted iron body, be non-rising stem and have an O-ring sealed stuffing box. The disk assembly shall be a double disc parallel seat

with four point wedging mechanism. A 2" square wrench nut shall be provided. The valve shall open left.

2.6 FREESTANDING FIRE HYDRANTS

- A. Dry-Barrel Fire Hydrants: Shall comply with ANSI/AWWA C502, shall be dry top design with O-ring sealed oil reservoir. Hydrant shall have a compression type main valve that closes with pressure, shall have a 5-1/4" main valve opening three way (two hose nozzles and one pumper nozzle), shall have a 200 psig maximum working pressure and a 400 psig maximum test pressure, the hydrant shall be Mueller Super Centurion A-423 or approved equal..

1. Manufacturers:

- a. American AVK Co.; Valves & Fittings Div.
- b. American Cast Iron Pipe Co.; American Flow Control Div.
- c. American Cast Iron Pipe Co.; Waterous Co. Subsidiary.
- d. American Foundry Group, Inc.
- e. Mueller Co.; Water Products Div.
- f. McWane, Inc.; Clow Valve Co. Div.
- g. McWane, Inc.; Kennedy Valve Div.
- h. United States Pipe and Foundry Company.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

- A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.
- B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below, unless otherwise indicated.
- C. Do not use flanges, unions, or keyed couplings for underground piping.
- D. Flanges, unions, keyed couplings, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.
- E. Underground Water-Service Piping: Use the following piping materials for each size range:

3.3 JOINT CONSTRUCTION

- A. Make pipe joints according to the following:

1. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.

3.4 PIPING INSTALLATION

- A. Install ductile-iron piping according to AWWA C600 and AWWA M41.
- B. Bury piping with depth of cover over top at least 42 inches.

3.5 ANCHORAGE INSTALLATION

- A. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:
 - 1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
- B. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.6 VALVE INSTALLATION

- A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

3.7 FIRE HYDRANT INSTALLATION

- A. General: Install each fire hydrant with separate gate valve in supply pipe, anchor with restrained joints or thrust blocks, and support in upright position.
- B. AWWA-Type Fire Hydrants: Comply with AWWA M17.

3.8 FIELD QUALITY CONTROL

- A. Piping Tests: Conduct piping tests before joints are covered and after thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
- B. Hydrostatic Tests: Test at not less than 1-1/2 times working pressure for 2 hours.
 - 1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.
- C. Prepare reports of testing activities.

3.9 CLEANING

- A. Clean and disinfect water-distribution piping as follows:
 - 1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.

2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or as described below:
 - a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
 - b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.
 - c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.
- B. Prepare reports of purging and disinfecting activities.
- C. After completing drinking fountain installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- D. Clean drinking fountains, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 332510

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SECTION 329200 - TURF AND GRASSES

PART 1 - GENERAL

All permanent and temporary seeding mixes and mulching requirements will be as per DNREC Sediment and Stormwater regulations and the Delaware Erosion and Sediment Control Handbook dated Latest revision, and as detailed on the plans in the “Permanent Stabilization” and “Temporary Stabilization” specifications.

1.01 RELATED DOCUMENTS

- A. The general provisions of the Contract, including the Conditions of the Contract (General, Supplementary and other Conditions, if any) and Division 1 as appropriate, apply to the Work specified in this Section.

1.02 SECTION INCLUDES

- A. Refer to Scope Information Sheets for this contract bound in the Project Manual. The Scope Information Sheets describe generally the work included in each contract, but the work is not necessarily limited to that described.

1.03 SUMMARY

- A. This Section includes the following:
 - 1. Seeding.
 - 2. Soil amendments.
 - 3. Initial maintenance.
 - 4. Warranties.
- B. Related Sections include the following:
 - 1. Division 31 Section “Earth Moving” for excavation, filling and backfilling, and rough grading.

1.04 DEFINITIONS

- A. Finish Grade: Elevation of finished surface of planting soil.
- B. Manufactured Soil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- C. Planting Soil: Native or imported topsoil, manufactured topsoil, or surface soil modified to become topsoil; mixed with soil amendments.
- D. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill immediately beneath planting soil.

1.05 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
- C. Product Certificates: For soil amendments and fertilizers, signed by product manufacturer.
- D. Material Test Reports: For existing surface soil and imported topsoil.
- E. Maintenance Instructions: Recommended procedures to be established by the Owner for maintenance of lawns during a calendar year. Submit before expiration of required maintenance periods.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful lawn establishment over the minimum of five years on projects of similar scope and size.
 - 1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when planting is in progress.
- B. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Topsoil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of topsoil.
 - 1. Report suitability of topsoil for lawn growth. State recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce a satisfactory topsoil.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Seed: Deliver seed in original sealed, labeled, and undamaged containers.

1.08 SCHEDULING

- A. Planting Restrictions: Plant lawn seed mix during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
 - 1. Spring Planting: April 15 to May 30.
 - 2. Fall Planting: September 1 to October 15.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.

1.09 LAWN MAINTENANCE

- A. Begin maintenance immediately after each area is planted and continue until acceptable lawn is established, but for not less than the following periods:
 - 1. Seeded Lawns: 60 days from date of Substantial Completion and until minimum 90% germination.
 - a. When full maintenance period has not elapsed before end of planting season, or if lawn is not fully established, continue maintenance during next planting season.
- B. Maintain and establish lawn by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth lawn.
 - 1. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch. Anchor as required to prevent displacement.
- C. Watering: Provide and maintain temporary piping, hoses, and lawn-watering equipment to convey water from sources and to keep lawn uniformly moist to a depth of 4 inches.
 - 1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 - 2. Water seeded lawn at a minimum rate of 1 inch per week.
 - 3. Water every other day the second week with 1 inch of water; and
 - 4. Water the third week twice at ½ inch of water each time.
- D. Mow lawn as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 40 percent of grass height. Remove no more than 40 percent of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
 - 1. Mow grass at least three times.
 - 2. Mow grass 2 to 2-1/2 inches high.

1.010 SPECIAL PROJECT WARRANTY

- A. Warranty lawns through the specified maintenance period, and until final acceptance.

PART 2 - PRODUCTS

2.01 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
- B. Seed Species: State-certified seed of grass species, as follows:

- C. Seed Species: Seed of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:
 - 1. DNREC Permanent Seeding Mix (See plans for mix design – Place seeding per DNREC specifications).
 - 2. DNREC Temporary Seeding Mix (See plans for mix design – Place seeding per DNREC specifications).

2.02 TOPSOIL

- A. Topsoil: pH range of 5.8 to 6.5, a minimum of 2 percent organic material content; free of stones 1 inch or larger in any dimension and meeting the following requirements.
 - 1. Size: 100 percent passing through a 3/4-inch sieve; 90 to 100 percent passing through a #4 sieve; and 0 to 100 percent passing through a #200 sieve.
 - 2. Sand Content: 2.000 mm to 0.05 mm, 40 to 50 percent.
 - 3. Silt Content: 0.05 mm to 0.005 mm, 30 to 40 percent.
 - 4. Clay Content: 0.005 mm and smaller, 10 to 30 percent.
 - 5. Topsoil Source: Reuse surface soil stockpiled on-site. Verify suitability of stockpiled surface soil to produce topsoil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
 - a. Supplement with imported or manufactured topsoil from local off-site sources when onsite quantities are insufficient. Obtain topsoil displaced from naturally well-drained construction sites where topsoil occurs at least 4 inches deep; do not obtain from bogs or marshes.

2.03 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural limestone containing a minimum 90 percent calcium carbonate with a minimum of 10 percent magnesium. Apply a minimum of 50 pounds per 1,000 sq. ft.
- B. Aluminum Sulfate: Commercial grade, unadulterated.
- C. Perlite: Horticultural perlite, soil amendment grade.
- D. Sand: Clean, washed, natural or manufactured, free of toxic materials.

2.04 ORGANIC SOIL AMENDMENTS

- A. Peat: Finely divided so completely decomposed and free of fibers that its biological identity is lost. Provide in granular form, free of hard lumps and with a pH range suitable for intended use.
- B. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

2.05 FERTILIZER

- A. Phosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid and 20 percent potash having a formula 0-20-20, applied to lawn areas at the rate of 50 pounds per 1,000 sq. ft. of area.
- B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: 10 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight at 12 pounds per 1,000 sq. ft. in areas not hydromulched.
 - 2. For hydromulch mixtures: Kapco 38-0-0 urea form nitrogen fertilizer at the rate of ten pounds per 1,000 sq. ft.

2.06 MULCHES

- A. Fiber Mulch: As per DNREC details.
- B. Tackifier: As per DNREC details.

2.07 HYDROMULCH GRASS MIXTURE

- A. Provide hydromulch mixture according to the following formula:
 - 1. Grass seed mix specified at eight pounds per 1,000 sq. ft.
 - 2. Kapco 38-0-0 Urea Form nitrogen fertilizer at the rate of ten pounds per 1,000 sq. ft.
 - 3. Tackifier.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas to receive lawns and grass for compliance with requirements and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect adjacent and adjoining areas from hydroseeding overspray.
- B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.03 LAWN PREPARATION

- A. Limit lawn subgrade preparation to areas to be planted.

- B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Apply 0-20-20 fertilizer at 50 pounds per 1,000 sq. ft.
 - 2. Spread topsoil, apply lime and fertilizer on surface, and thoroughly blend soil mix.
 - C. Changed subgrades to be topsoiled. Spread topsoil to a depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
 - a. Spread approximately one-half the thickness of topsoil over loosened subgrade. Spread remainder of topsoil.
 - b. Reduce elevation of planting soil to allow for soil thickness of any sod.
 - c. Spread lime, 0-20-20 and fertilizer, rototill into the top four inches of soil.
 - D. Unchanged Subgrades: If lawns are to be planted in areas unaltered or undisturbed by excavating, grading, or surface soil stripping operations, prepare surface soil as follows:
 - 1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
 - 2. Loosen surface soil to a depth of at least of 6 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches of soil. Till soil to a homogeneous mixture of fine texture.
 - a. Apply 0-20-20, lime, and other fertilizer directly to surface soil before loosening.
 - 3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
 - 4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.
 - E. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch (13 mm) of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future. The maximum compaction for the lawn area is 80%.
 - F. Moisten prepared lawn areas before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
 - G. Restore areas if eroded or otherwise disturbed after finish grading and before planting.
- 3.04 SEEDING
- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
 - 1. Do not use wet seed or seed that is moldy or otherwise damaged.
 - B. Sow seed at the rate of 8 pounds per 1,000 sq. ft.

- C. Rake seed lightly into top 1/8 inch of topsoil, roll lightly, and water with fine spray.
- D. Protect seeded areas by spreading wood fiber mulch. Spread uniformly at a minimum rate of 60 pounds per 1,000 sq. ft. (2,600 pounds per acre) with tackifier to form a continuous blanket over seeded areas. Spread by hand, hydromulcher, or other suitable equipment.

3.05 HYDROSEEDING

- A. Presoak areas by water truck or other approved method to a depth of three inches immediately prior to hydromulch installation.
- B. Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
- C. Begin slurry preparation by adding water to the tank when the engine is at 1/2 throttle. When the water level has reached the height of the agitator shaft, and good recirculation has been established, add fertilizer to the mixture (the tank will be at least 1/3 filled with water at this time). Open the engine throttle to full speed when the tank is 1/2 filled with water, then add mulch by the time the tank is 2/3 to 3/4 full. At 3/4 full, add seed.
- D. Begin spraying immediately when the tank is full and slurry is mixed.
- E. Apply the slurry in a downward drilling motion via a fan stream nozzle ensuring that all of the components enter and mix with the soil to a depth of two inches.
- F. After planting operations are finished, clean all paved areas which have become strewn with soil or other material by sweeping and, if necessary, washing.
- G. Limitations: If slurry components are left for more than two hours in the hydromulch machine, add 50 percent more of the originally specified seed mix. Add 75 percent more of the original seed mix to any slurry mixture that has not been applied within six hours after mixing. If slurry mixture has not been applied within eight hours of mixing, it will be considered rejected. Dispose of such mixture off site at no extra cost to the Owner.

3.06 SATISFACTORY LAWNS

- A. Satisfactory Seeded Lawn: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. Bare spots will be reseeded until the grass is a close uniform stand.
- B. Satisfactory Sodded Lawn: At end of maintenance period, a healthy, well-rooted, even-colored, viable lawn has been established, free of weeds, open joints, bare areas, and surface irregularities.
- C. Reestablish lawns that do not comply with requirements and continue maintenance until lawns are satisfactory.

3.07 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by lawn work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

- B. Erect barricades and warning signs as required to protect newly planted areas from traffic. Maintain barricades throughout maintenance period and remove after lawn is established.
- C. Remove erosion-control measures after grass establishment period.

END OF SECTION 329200

SECTION – 334100 STORM DRAINAGE AND SANITARY SEWERAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- 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 gravity-flow storm drainage and sanitary sewer outside the building, with the following components:
 - 1. PVC storm and sanitary pipe and fittings
 - 2. RCP storm pipe and flared end section
 - 3. Cleanouts.
 - 4. Drains.
 - 5. Pre-cast concrete catch basins and manholes.
 - 6. Pre-cast concrete pond outlet structure

1.3 DEFINITIONS

- A. RCP: Reinforced concrete pipe
- B. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

- A. Gravity-Flow, pipe joints shall be at least silt-tight, unless otherwise indicated.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. RCP pipe and fittings.
 - 2. Cleanouts
 - 3. PVC SDR-26 piping and fittings
 - 4. Reinforced concrete flared end sections
 - 5. Storm and Sanitary structures (manholes, manhole seals, catch basins, etc.)
- B. Shop Drawings: For the following:
 - 1. Manholes: Include plans, elevations, sections, details, and frames and covers. Include design calculations, and concrete design-mix report for cast-in-place manholes.
 - 2. Catch Basins: Include plans, elevations, sections, details, and frames, covers, and grates.
 - 3. Junction Boxes: Include plans, elevations, sections, details, frames, and covers.
 - 4. HDPE to Concrete Connection: Provide ADS specifications or approved equal (as per drawing detail).

- C. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
- D. Field quality-control test reports.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic manholes, pipe, and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.
- C. Handle manholes according to manufacturer's written rigging instructions.
- D. Handle catch basins according to manufacturer's written rigging instructions.

1.7 PROJECT CONDITIONS

- A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - 1. Notify Construction Manager no fewer than two days in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.

2.3 PE PIPE AND FITTINGS

- A. Corrugated PE Pipe and Fittings: AASHTO M 294M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
2. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

2.4 PVC PIPE AND FITTINGS

- A. PVC Sewer Pipe and Fittings, 4" to 15" diameter: ASTM D 3034, SDR-26 with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.
- B. PVC Sewer Pipe and Fittings, 18" diameter and Larger: ASTM F 679, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

2.5 CONCRETE PIPE AND FITTINGS

- A. Reinforced-Concrete Sewer Pipe (RCP) and Fittings: ASTM C 76, with bell-and-spigot ends and gasketed joints with ASTM C 443, rubber gaskets.

2.6 NONPRESSURE-TYPE PIPE COUPLINGS

- A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
- B. Sleeve Materials:
 1. For Concrete Pipes: ASTM C 443, rubber.
 2. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 3. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

2.7 CLEANOUTS

- A. Gray-Iron Cleanouts (paved areas): ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
 1. Manufacturers:
 - a. Josam Company.
 - b. MIFAB Manufacturing, Inc.
 2. Top-Loading Classification(s): Heavy duty.
 3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.
- B. PVC Cleanouts (lawn areas): Schedule-40 PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.
 1. Manufacturers:
 - a. IPS Corporation.
 - b. NDS Inc.

2.8 DRAINAGE STRUCTURES

- A. Standard Precast Concrete Manholes, Junction Boxes, and Catch Basins: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
1. Diameter: 48 inches minimum, unless otherwise indicated.
 2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
 3. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
 4. Riser Sections: 4-inch minimum thickness, and lengths to provide depth indicated.
 5. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
 6. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
 7. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
 8. Steps: Individual FRP steps wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 48 inches.
 9. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and diameter matching manhole frame and cover. Include sealant recommended by ring manufacturer.
 10. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover.
 11. Protective Coating: Plant-applied, SSPC-Paint 16, coal-tar 10-mil minimum thickness applied to exterior and interior surfaces.
 12. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch-minimum width flange and 26-inch-diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."

2.9 CONCRETE

- A. General: Cast-in-place concrete according to ACI 318/318R, ACI 350R, and the following:
1. Cement: ASTM C 150, Type II.
 2. Fine Aggregate: ASTM C 33, sand.
 3. Coarse Aggregate: ASTM C 33, crushed gravel.
 4. Water: Potable.
- B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water-cementitious materials ratio.
1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
 2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.
- C. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water-cementitious materials ratio.
1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
 2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

2.10 PIPE OUTLETS

- A. Head Walls (N/A): Cast-in-place reinforced concrete, with apron and tapered sides.
- B. Riprap Stilling Basins (N/A): Place as per DNREC standards and drawing detail with rip-rap size and thickness as specified on drawings.
- C. Filter Stone: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. FS-2, No. 4 screen opening, average-size graded stone.

2.11 STORMWATER INLETS

- A. Gutter Inlets: Made with horizontal gutter openings as per DelDOT standards. Include heavy-duty frames and Type 3 Bicycle Safe grates.
- B. Combination Inlets: Made with vertical curb and horizontal gutter openings as per DelDOT standards. Include heavy-duty frames and Type 3 Bicycle Safe grates.
- C. Frames and Grates: Heavy duty frames and Type 3 Bicycle Safe grates.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in Division 2 Section "Earthwork."

3.2 PIPING APPLICATIONS

- A. Pipe couplings and special pipe fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.
 - 1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping, unless otherwise indicated.
 - a. Flexible or rigid couplings for same or minor difference OD pipes.
 - b. Unshielded, increaser/reducer-pattern, flexible or rigid couplings for pipes with different OD.
 - c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.
 - 2. Use pressure-type pipe couplings for force-main joints.
- B. Special Pipe Fittings: Use for pipe expansion and deflection. Pipe couplings and special pipe fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.
- C. Gravity-Flow, Nonpressure Sewer Piping: Use the following pipe materials for each size range:
 - 1. Reinforced-concrete sewer pipe and fittings, gaskets, and gasketed joints.
 - 2. PVC sewer pipe and fittings, gaskets, and gasketed joints (NPS 4 and NPS 6).

3. PVC sewer pipe and fittings, gaskets, and gasketed joints (NPS 8 to NPS 12).

3.3 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
- C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or a combination of both.
- F. Install gravity-flow, nonpressure drainage piping according to the following:
 1. Install piping pitched down in direction of flow, at minimum slope of 0.005 ft/ft, unless otherwise indicated on plans.
 2. Install PE corrugated sewer piping according to CPPA's "Recommended Installation Practices for Corrugated Polyethylene Pipe and Fittings."
 3. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
 4. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

3.4 PIPE JOINT CONSTRUCTION

- A. Basic pipe joint construction is specified in Division 2 Section "Piped Utilities - Basic Materials and Methods." Where specific joint construction is not indicated, follow piping manufacturer's written instructions.
- B. Join gravity-flow, nonpressure drainage piping according to the following:
 1. Join corrugated PE piping according to CPPA 100 and the following:
 - a. Use silttight couplings for Type 1, silttight joints.
 - b. Use soiltight couplings for Type 2, soiltight joints.
 2. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric gasket joints.
 3. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasket joints.
 4. Join dissimilar pipe materials with nonpressure-type flexible or rigid couplings.

- C. Join dissimilar pipe materials with pressure-type couplings.

3.5 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
 - 1. Use Medium-Duty, top-loading classification cleanouts in **earth or unpaved/paved foot-traffic** areas.
 - 2. Use Heavy-Duty, top-loading classification cleanouts in loading/**vehicle-traffic service** areas.
- B. Set cleanout frames and covers in earth in cast-in-place concrete block, 18 by 18 by 12 inches deep (or as per drawing detail). Set with tops 1 inch above surrounding earth grade.
- C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.6 MANHOLE INSTALLATION

- A. General: Install manholes, complete with appurtenances and accessories indicated.
- B. Install precast concrete manhole sections according to ASTM C 891.
- C. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere, unless otherwise indicated.

3.7 CATCH BASIN INSTALLATION

- A. Construct catch basins to sizes and shapes indicated.
- B. Set frames and grates to elevations indicated.

3.8 DRAIN INSTALLATION

- A. Install type of drains in locations indicated.
 - 1. Use Light-Duty, top-loading classification drains in [earth or unpaved foot-traffic areas.
 - 2. Use Medium-Duty, top-loading classification drains in paved foot-traffic areas.
 - 3. Use Heavy-Duty, top-loading classification drains in loading/vehicle-traffic service areas.
 - 4. Use Extra-Heavy-Duty, top-loading classification drains in [roads] <Insert area>.
- B. Embed drains in 6-inch minimum concrete around bottom and sides (see drawing detail).
- C. Fasten grates to drains if indicated.
- D. Set drain frames and covers with tops flush with pavement surface.
- E. Assemble trench sections with flanged joints.

- F. Embed trench sections in 6-inch minimum concrete around bottom and sides (see drawing detail).

3.9 STORM PIPE OUTLET INSTALLATION

- A. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.

3.10 CONCRETE PLACEMENT

- A. Place cast-in-place concrete according to ACI 318/318R.

3.11 STORMWATER INLET AND OUTLET INSTALLATION

- A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.
- B. Construct riprap of broken stone, as indicated.
- C. Install outlets that spill onto grade, anchored with concrete, where indicated.
- D. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.
- E. Construct energy dissipaters at outlets, as indicated.

3.12 DRAINAGE SYSTEM INSTALLATION

- A. Assemble and install components according to manufacturer's written instructions.
- B. Install with top surfaces of components, except piping, flush with finished surface.
- C. Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturer.

3.13 CONNECTIONS

- A. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Division 22 Section "Facility Storm Drainage Piping."
- B. Connect force-main piping to building's storm drainage force mains specified in Division 22 Section "Facility Storm Drainage Piping." Terminate piping where indicated.
- C. Make connections to existing piping and underground manholes.
 - 1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
 - 2. Make branch connections from side into existing piping, NPS 4 to NPS 20. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.

3. Make branch connections from side into existing piping, NPS 21 or larger, or to underground manholes and structures by cutting into existing unit and creating an opening large enough to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe, manhole, or structure wall, encase entering connection in 6 inches of concrete for minimum length of 12 inches to provide additional support of collar from connection to undisturbed ground.
 - a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi unless otherwise indicated.
 - b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
 4. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.
- D. Connect to sediment interceptors specified in Division 22 Section "Sanitary Waste Interceptors."
- E. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.
 - a. Flexible couplings for same or minor difference OD pipes.
 - b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
 - c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.
 2. Use pressure-type pipe couplings for force-main joints.

3.14 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

- A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
1. Close open ends of piping with at least 8-inch thick, brick masonry bulkheads.
 2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.
- B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:
1. Remove manhole or structure and close open ends of remaining piping.

2. Remove top of manhole or structure down to at least 36 inches below final grade. Fill to within 12 inches of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

C. Backfill to grade according to Division 31 Section "Earth Moving."

3.15 IDENTIFICATION

A. Materials and their installation are specified in division 2 Section "Earthwork." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.16 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - c. Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.
3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

3.17 CLEANING

A. Clean interior of piping, flared end sections, and structures of dirt and superfluous materials as directed by CCR and Engineer.

END OF SECTION 334100