

SECTION 26 05 11 REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section applies to all sections of Division 26.
- B. Furnish and install electrical systems, materials, equipment, and accessories in accordance with the specifications and drawings. Capacities and ratings of motors, transformers, conductors and cable, switchboards, switchgear, panelboards, motor control centers, generators, automatic transfer switches, and other items and arrangements for the specified items are shown on the drawings.
- C. Electrical service entrance equipment and arrangements for temporary and permanent connections to the electric utility company's system shall conform to the electric utility company's requirements. Coordinate fuses, circuit breakers and relays with the electric utility company's system, and obtain electric utility company approval for sizes and settings of these devices.
- D. Conductor ampacities specified or shown on the drawings are based on copper conductors, with the conduit and raceways sized per NEC. Aluminum conductors are prohibited.

1.2 MINIMUM REQUIREMENTS

- A. The International Building Code (IBC), National Electrical Code (NEC), Underwriters Laboratories, Inc. (UL), and National Fire Protection Association (NFPA) codes and standards are the minimum requirements for materials and installation.
- B. The drawings and specifications shall govern in those instances where requirements are greater than those stated in the above codes and standards.

1.3 TEST STANDARDS

- A. All materials and equipment shall be listed, labeled, or certified by a Nationally Recognized Testing Laboratory (NRTL) to meet Underwriters Laboratories, Inc. (UL), standards where test standards have been established. Materials and equipment which are not covered by UL standards will be accepted, providing that materials and equipment are listed, labeled, certified or otherwise determined to meet the safety requirements of a NRTL. Materials and equipment which no NRTL accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested in accordance with national industrial standards, such as ANSI, NEMA, and NETA. Evidence of compliance shall include certified test reports and definitive shop drawings.

B. Definitions:

1. **Listed:** Materials and equipment included in a list published by an organization that is acceptable to the Authority Having Jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production or listed materials and equipment or periodic evaluation of services, and whose listing states that the materials and equipment either meets appropriate designated standards or has been tested and found suitable for a specified purpose.
2. **Labeled:** Materials and equipment to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the Authority Having Jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled materials and equipment, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
3. **Certified:** Materials and equipment which:
 - a. Have been tested and found by a NRTL to meet nationally recognized standards or to be safe for use in a specified manner.
 - b. Are periodically inspected by a NRTL.
 - c. Bear a label, tag, or other record of certification.
4. **Nationally Recognized Testing Laboratory:** Testing laboratory which is recognized and approved by the Secretary of Labor in accordance with OSHA regulations.

1.4 QUALIFICATIONS (PRODUCTS AND SERVICES)

- A. **Manufacturer's Qualifications:** The manufacturer shall regularly and currently produce, as one of the manufacturer's principal products, the materials and equipment specified for this project, and shall have manufactured the materials and equipment for at least three years.
- B. **Product Qualification:**
 1. Manufacturer's materials and equipment shall have been in satisfactory operation, on three installations of similar size and type as this project, for at least three years.
 2. The Government reserves the right to require the Contractor to submit a list of installations where the materials and equipment have been in operation before approval.
- C. **Service Qualifications:** There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation

within four hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.5 APPLICABLE PUBLICATIONS

- A. Applicable publications listed in all Sections of Division 26 are the latest issue, unless otherwise noted.
- B. Products specified in all sections of Division 26 shall comply with the applicable publications listed in each section.

1.6 MANUFACTURED PRODUCTS

- A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, and for which replacement parts shall be available.
- B. When more than one unit of the same class or type of materials and equipment is required, such units shall be the product of a single manufacturer.
- C. Equipment Assemblies and Components:
 - 1. Components of an assembled unit need not be products of the same manufacturer.
 - 2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.
 - 3. Components shall be compatible with each other and with the total assembly for the intended service.
 - 4. Constituent parts which are similar shall be the product of a single manufacturer.
- D. Factory wiring and terminals shall be identified on the equipment being furnished and on all wiring diagrams.
- E. When Factory Testing Is Specified:
 - 1. The Government shall have the option of witnessing factory tests. The Contractor shall notify the Government through the COTR a minimum of 15 working days prior to the manufacturer's performing the factory tests.
 - 2. Four copies of certified test reports shall be furnished to the COTR two weeks prior to final inspection and not more than 90 days after completion of the tests.
 - 3. When materials and equipment fail factory tests, and re-testing and re-inspection is required, the Contractor shall be liable for all additional expenses for the Government to witness re-testing.

1.7 VARIATIONS FROM CONTRACT REQUIREMENTS

- A. Where the Government or the Contractor requests variations from the contract requirements, the connecting work and related components shall include, but not be

limited to additions or changes to branch circuits, circuit protective devices, conduits, wire, feeders, controls, panels and installation methods.

1.8 MATERIALS AND EQUIPMENT PROTECTION

- A. Materials and equipment shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold and rain.
 - 1. Store materials and equipment indoors in clean dry space with uniform temperature to prevent condensation.
 - 2. During installation, equipment shall be protected against entry of foreign matter, and be vacuum-cleaned both inside and outside before testing and operating. Compressed air shall not be used to clean equipment. Remove loose packing and flammable materials from inside equipment.
 - 3. Damaged equipment shall be repaired or replaced, as determined by the COTR.
 - 4. Painted surfaces shall be protected with factory installed removable heavy kraft paper, sheet vinyl or equal.
 - 5. Damaged paint on equipment shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.

1.9 WORK PERFORMANCE

- A. All electrical work shall comply with the requirements of NFPA 70 (NEC), NFPA 70B, NFPA 70E, OSHA Part 1910 subpart J – General Environmental Controls, OSHA Part 1910 subpart K – Medical and First Aid, and OSHA Part 1910 subpart S – Electrical, in addition to other references required by contract.
- B. Job site safety and worker safety is the responsibility of the Contractor.
- C. Electrical work shall be accomplished with all affected circuits or equipment de-energized. When an electrical outage cannot be accomplished in this manner for the required work, the following requirements are mandatory:
 - 1. Electricians must use full protective equipment (i.e., certified and tested insulating material to cover exposed energized electrical components, certified and tested insulated tools, etc.) while working on energized systems in accordance with NFPA 70E.
 - 2. Before initiating any work, a job specific work plan must be developed by the Contractor with a peer review conducted and documented by the COTR and Medical Center staff. The work plan must include procedures to be used on and near the live electrical equipment, barriers to be installed, safety equipment to be used, and exit pathways.

3. Work on energized circuits or equipment cannot begin until prior written approval is obtained from the COTR.
- D. For work that affects existing electrical systems, arrange, phase and perform work to assure minimal interference with normal functioning of the facility. Refer to Article OPERATIONS AND STORAGE AREAS under Section 01 00 00, GENERAL REQUIREMENTS.
- E. New work shall be installed and connected to existing work neatly, safely and professionally. Disturbed or damaged work shall be replaced or repaired to its prior conditions, as required by Section 01 00 00, GENERAL REQUIREMENTS.
- F. Coordinate location of equipment and conduit with other trades to minimize interference.

1.10 EQUIPMENT INSTALLATION AND REQUIREMENTS

- A. Equipment location shall be as close as practical to locations shown on the drawings.
- B. Working clearances shall not be less than specified in the NEC.
- C. Inaccessible Equipment:
 1. Where the Government determines that the Contractor has installed equipment not readily accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the Government.
 2. "Readily accessible" is defined as being capable of being reached quickly for operation, maintenance, or inspections without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit and raceways.
- D. Electrical service entrance equipment and arrangements for temporary and permanent connections to the electric utility company's system shall conform to the electric utility company's requirements. Coordinate fuses, circuit breakers and relays with the electric utility company's system, and obtain electric utility company approval for sizes and settings of these devices.

1.11 EQUIPMENT IDENTIFICATION

- A. In addition to the requirements of the NEC, install an identification sign which clearly indicates information required for use and maintenance of items such as switchboards and switchgear, panelboards, cabinets, motor controllers, fused and non-fused safety switches, generators, automatic transfer switches, separately enclosed circuit breakers, individual breakers and controllers in switchboards, switchgear and motor control assemblies, control devices and other significant equipment.

- B. Identification signs for Normal Power System equipment shall be laminated black phenolic resin with a white core with engraved lettering. Identification signs for Essential Electrical System (EES) equipment, as defined in the NEC, shall be laminated red phenolic resin with a white core with engraved lettering. Lettering shall be a minimum of 12 mm (1/2 inch) high. Identification signs shall indicate equipment designation, rated bus amperage, voltage, number of phases, number of wires, and type of EES power branch as applicable. Secure nameplates with screws.
- C. Install adhesive arc flash warning labels on all equipment as required by NFPA 70E. Label shall indicate the arc hazard boundary (inches), working distance (inches), arc flash incident energy at the working distance (calories/cm²), required PPE category and description including the glove rating, voltage rating of the equipment, limited approach distance (inches), restricted approach distance (inches), prohibited approach distance (inches), equipment/bus name, date prepared, and manufacturer name and address.

1.12 SUBMITTALS

- A. Submit to the COTR in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. The Government's approval shall be obtained for all materials and equipment before delivery to the job site. Delivery, storage or installation of materials and equipment which has not had prior approval will not be permitted.
- C. All submittals shall include six copies of adequate descriptive literature, catalog cuts, shop drawings, test reports, certifications, samples, and other data necessary for the Government to ascertain that the proposed materials and equipment comply with drawing and specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify specific materials and equipment being submitted.
- D. Submittals for individual systems and equipment assemblies which consist of more than one item or component shall be made for the system or assembly as a whole. Partial submittals will not be considered for approval.
 - 1. Mark the submittals, "SUBMITTED UNDER SECTION _____".
 - 2. Submittals shall be marked to show specification reference including the section and paragraph numbers.
 - 3. Submit each section separately.
- E. The submittals shall include the following:
 - 1. Information that confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data

sheets, shop drawings, manuals, pictures, nameplate data, and test reports as required.

3. Elementary and interconnection wiring diagrams for communication and signal systems, control systems, and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams.
 4. Parts list which shall include information for replacement parts and ordering instructions, as recommended by the equipment manufacturer.
- F. Maintenance and Operation Manuals:
1. Submit as required for systems and equipment specified in the technical sections. Furnish in hardcover binders or an approved equivalent.
 2. Inscribe the following identification on the cover: the words "MAINTENANCE AND OPERATION MANUAL," the name and location of the system, material, equipment, building, name of Contractor, and contract name and number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the material or equipment.
 3. Provide a table of contents and assemble the manual to conform to the table of contents, with tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in.
 4. The manuals shall include:
 - a. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.
 - b. A control sequence describing start-up, operation, and shutdown.
 - c. Description of the function of each principal item of equipment.
 - d. Installation instructions.
 - e. Safety precautions for operation and maintenance.
 - f. Diagrams and illustrations.
 - g. Periodic maintenance and testing procedures and frequencies, including replacement parts numbers.
 - h. Performance data.
 - i. Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare and replacement parts, and name of servicing organization.

- j. List of factory approved or qualified permanent servicing organizations for equipment repair and periodic testing and maintenance, including addresses and factory certification qualifications.
- G. Approvals will be based on complete submission of shop drawings, manuals, test reports, certifications, and samples as applicable.
- H. After approval and prior to installation, furnish the COTR with one sample of each of the following:
 - 1. A minimum 300 mm (12 inches) length of each type and size of wire and cable along with the tag from the coils or reels from which the sample was taken. The length of the sample shall be sufficient to show all markings provided by the manufacturer.
 - 2. Each type of conduit coupling, bushing, and termination fitting.
 - 3. Conduit hangers, clamps, and supports.
 - 4. Duct sealing compound.
 - 5. Each type of receptacle, toggle switch, lighting control sensor, outlet box, manual motor starter, device wall plate, engraved nameplate, wire and cable splicing and terminating material, and branch circuit single pole molded case circuit breaker.

1.13 SINGULAR NUMBER

- A. Where any device or part of equipment is referred to in these specifications in the singular number (e.g., "the switch"), this reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

1.15 ACCEPTANCE CHECKS AND TESTS

- A. The Contractor shall furnish the instruments, materials, and labor for tests.
- B. Where systems are comprised of components specified in more than one section of Division 26, the Contractor shall coordinate the installation, testing, and adjustment of all components between various manufacturer's representatives and technicians so that a complete, functional, and operational system is delivered to the Government.
- C. When test results indicate any defects, the Contractor shall repair or replace the defective materials or equipment, and repeat the tests. Repair, replacement, and retesting shall be accomplished at no additional cost to the Government.

1.16 WARRANTY

- A. All work performed and all equipment and material furnished under this Division shall be free from defects and shall remain so for a period of one year from the date of acceptance of the entire installation by the Contracting Officer for the Government.

1.17 INSTRUCTION

- A. Instruction to designated Government personnel shall be provided for the particular equipment or system as required in each associated technical specification section.
- B. Furnish the services of competent instructors to give full instruction in the adjustment, operation, and maintenance of the specified equipment and system, including pertinent safety requirements. Instructors shall be thoroughly familiar with all aspects of the installation, and shall be trained in operating theory as well as practical operation and maintenance procedures.
- C. A training schedule shall be developed and submitted by the Contractor and approved by the COTR at least 30 days prior to the planned training.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

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SECTION 26 05 13 MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of medium-voltage cables, indicated as cable or cables in this section, and medium-voltage cable splices and terminations.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- B. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for medium-voltage cables.
- D. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Manholes and ducts for medium-voltage cables.
- E. Section 26 12 19, PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS: Medium-voltage cable terminations for use in pad-mounted, liquid-filled, medium-voltage transformers.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Medium-voltage cables shall be thoroughly tested at the factory per NEMA WC 74 to ensure that there are no electrical defects. Factory tests shall be certified.

1.5 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit the following data for approval:
 - 1) Complete electrical ratings.

- 2) Installation instructions.
2. Samples:
 - a. After approval and prior to installation, furnish the COTR with a sample of each type and size of cable per the requirements of Section 25 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
3. Certifications:
 - a. Factory Test Reports: Submit certified factory production test reports for approval.
 - b. Field Test Reports: Submit field test reports for approval.
 - c. Compatibility: Submit a certificate from the cable manufacturer that the splices and terminations are approved for use with the cable.
 - d. Two weeks prior to final inspection, submit the following.
 - 1) Certification by the manufacturer that the cables, splices, and terminations conform to the requirements of the drawings and specifications.
 - 2) Certification by the Contractor that the cables, splices, and terminations have been properly installed and tested.
 - 3) Certification by the Contractor that each splice and each termination were completely installed in a single continuous work period by a single qualified worker without any overnight interruption.
4. Qualified Worker Approval:
 - a. Qualified workers who install and test cables, splices, and terminations shall have not fewer than five years of experience splicing and terminating cables equivalent to those being spliced and terminated, including experience with the materials in the approved splices and terminations.
 - b. Furnish satisfactory proof of such experience for each qualified worker who splices or terminates the cables.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American Society for Testing and Materials (ASTM):
B3-01 (2007) Standard Specification for Soft or Annealed Copper Wire
- C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

- 48-09 Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
- 386-95 Separable Insulated Connector Systems for Power Distribution Systems above 600 V
- 400-01 Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems
- 400.2-04 Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)
- 400.3-06 Guide for Partial Discharge Testing of Shielded Power Cable Systems in a Field Environment
- 404-00 Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
- D. National Electrical Manufacturers Association (NEMA):
 - WC 71-99 Non-Shielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy
 - WC 74-06 5-46 KV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy
- E. National Fire Protection Association (NFPA):
 - 70-11 National Electrical Code (NEC)
- F. Underwriters Laboratories (UL):
 - 1072-06 Medium-Voltage Power Cables

1.7 SHIPMENT AND STORAGE

- A. Cable shall be shipped on reels such that it is protected from mechanical injury. Each end of each length of cable shall be hermetically sealed with manufacturer's end caps and securely attached to the reel.
- B. Cable stored and/or cut on site shall have the ends turned down, and sealed with cable manufacturer's standard cable end seals, or field-installed heat-shrink cable end seals.

PART 2 - PRODUCTS

2.1 CABLE

- A. Cable shall be in accordance with the NEC and NEMA WC 71, WC 74, and UL 1072.
- B. Single conductor stranded copper conforming to ASTM B3.

C. Voltage Rating:

1. 15,000 V cable shall be used on all distribution systems with voltages ranging from 5,000 V to 15,000 V.

D. Insulation:

1. Insulation level shall be 133%.
2. Types of insulation:
 - a. Cable type abbreviation, EPR: Ethylene propylene rubber insulation shall be thermosetting, light and heat stabilized.
 - b. Cable type abbreviation, XLP or XLPE: cross-linked polyethylene insulation shall be thermosetting, light and heat stabilized, and chemically cross-linked.

E. Insulation shield shall be semi-conducting. Conductor shield shall be semi-conducting.

F. Insulation shall be wrapped with copper shielding tape, helically-applied over semi-conducting insulation shield.

G. Heavy duty, overall protective polyvinyl chloride jacket shall enclose every cable. The manufacturer's name, cable type and size, and other pertinent information shall be marked or molded clearly on the overall protective jacket.

H. Cable temperature ratings for continuous operation, emergency overload operation, and short circuit operation shall be not less than the NEC, NEMA WC 71, or NEMA WC 74 standard for the respective cable.

2.2 SPLICES AND TERMINATIONS

A. Materials shall be compatible with the cables being spliced and terminated, and shall be suitable for the prevailing environmental conditions.

B. In locations where moisture might be present, the splices shall be watertight. In manholes and pullboxes, the splices shall be submersible.

C. Splices:

1. Shall comply with IEEE 404. Include all components required for complete splice, with detailed instructions.

D. Terminations:

1. Shall comply with IEEE 48. Include shield ground strap for shielded cable terminations.
2. Class 3 terminations for outdoor use: Kit with stress cone and compression-type connector.

3. Load-break terminations for indoor and outdoor use: 200 A loadbreak premolded rubber elbow connectors with bushing inserts, suitable for submersible applications. Separable connectors shall comply with the requirements of IEEE 386, and shall be interchangeable between suppliers. Allow sufficient slack in medium-voltage cable, ground, and drain wires to permit elbow connectors to be moved to their respective parking stands.
4. Ground metallic cable shields with a device designed for that purpose, consisting of a solderless connector enclosed in watertight rubber housing covering the entire assembly.
5. Provide insulated cable supports to relieve any strain imposed by cable weight or movement. Ground cable supports to the grounding system.

2.3 FIREPROOFING TAPE

- A. Fireproofing tape shall be flexible, non-corrosive, self-extinguishing, arcproof, and fireproof intumescent elastomer. Securing tape shall be glass cloth electrical tape not less than 0.18 mm (7 mils) thick, and 19 mm (0.75 inch) wide.

PART 3 - EXECUTION

3.1 GENERAL

- A. Installation shall be in accordance with the NEC, as shown on the drawings, and per manufacturer's instructions.
- B. Cable shall be installed in conduit above grade and duct bank below grade.
- C. All cables of a feeder shall be pulled simultaneously.
- D. Conductors of different systems (e.g., 5kV and 15kV) shall not be installed in the same raceway.
- E. Splice the cables only in manholes and pullboxes.
- F. Ground shields in accordance with Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- G. Cable maximum pull length, maximum pulling tension, and minimum bend radius shall conform with the recommendations of the manufacturer.
- H. Use suitable lubricating compounds on the cables to prevent pulling damage. Provide compounds that are not injurious to the cable jacket and do not harden or become adhesive.
- I. Seal the cable ends prior to pulling, to prevent the entry of moisture or lubricant.

3.2 PROTECTION DURING SPLICING OPERATIONS

- A. Blowers shall be provided to force fresh air into manholes where free movement or circulation of air is obstructed. Waterproof protective coverings shall be available on the work site to provide protection against moisture while a splice is being made. Pumps shall be used to keep manholes dry during splicing operations. Under no conditions shall a splice or termination be made that exposes the interior of a cable to moisture. A manhole ring at least 150 mm (6 inches) above ground shall be used around the manhole entrance to keep surface water from entering the manhole. Unused ducts shall be plugged and water seepage through ducts in use shall be stopped before splicing.

3.3 PULLING CABLES IN DUCTS AND MANHOLES

- A. Cables shall be pulled into ducts with equipment designed for this purpose, including power-driven winches, cable-feeding flexible tube guides, cable grips, pulling eyes, and lubricants. A sufficient number of qualified workers and equipment shall be employed to ensure the careful and proper installation of the cable.
- B. Cable reels shall be set up at the side of the manhole opening and above the duct or hatch level, allowing cables to enter through the opening without reverse bending. Flexible tube guides shall be installed through the opening in a manner that will prevent cables from rubbing on the edges of any structural member.
- C. Cable shall be unreeled from the top of the reel. Pay-out shall be carefully controlled. Cables to be pulled shall be attached through a swivel to the main pulling wire by means of a suitable cable grip and pulling eye.
- D. Woven-wire cable grips shall be used to grip the cable end when pulling small cables and short straight lengths of heavier cables.
- E. Pulling eyes shall be attached to the cable conductors to prevent damage to the cable structure.
- F. Cables shall be liberally coated with a suitable lubricant as they enter the tube guide or duct. Rollers, sheaves, or tube guides around which the cable is pulled shall conform to the minimum bending radius of the cable.
- G. Cables shall be pulled into ducts at a reasonable speed. Cable pulling using a vehicle shall not be permitted. Pulling operations shall be stopped immediately at any indication of binding or obstruction, and shall not be resumed until the potential for damage to the cable is corrected. Sufficient slack shall be provided for free movement of cable due to expansion or contraction.

- H. Splices in manholes shall be firmly supported on cable racks. Cable ends shall overlap at the ends of a section to provide sufficient undamaged cable for splicing.
- I. Cables cut in the field shall have the cut ends immediately sealed to prevent entrance of moisture.

3.4 SPLICES AND TERMINATIONS

- A. Install the materials as recommended by the manufacturer, including precautions pertaining to air temperature and humidity during installation.
- B. Installation shall be accomplished by qualified workers trained to perform medium-voltage equipment installations. Use tools as recommended or provided by the manufacturer. All manufacturer's instructions shall be followed.
- C. Splices in manholes shall be located midway between cable racks on walls of manholes, and supported with cable arms at approximately the same elevation as the enclosing duct.
- D. Where the Government determines that unsatisfactory splices and terminations have been installed, the Contractor shall replace the unsatisfactory splices and terminations with approved material at no additional cost to the Government.

3.5 FIREPROOFING

- A. Cover all cable segments exposed in manholes and pullboxes with fireproofing tape.
- B. Apply the tape in a single layer, wrapped in a half-lap manner, or as recommended by the manufacturer. Extend the tape not less than 25 mm (1 inch) into each duct.
- C. At each end of a taped cable section, secure the fireproof tape in place with glass cloth tape.

3.6 CIRCUIT IDENTIFICATION OF FEEDERS

- A. In each manhole and pullbox, install permanent identification tags on each circuit's cables to clearly designate the circuit identification and voltage. The tags shall be the embossed brass type, 40 mm (1.5 inches) in diameter and 40 mils thick. Attach tags with plastic ties. Position the tags so they will be easy to read after the fireproofing tape is installed.

3.7 ACCEPTANCE CHECKS AND TESTS

- A. Perform tests in accordance with the manufacturer's recommendations. Include the following visual and electrical inspections.
- B. Test equipment, labor, and technical personnel shall be provided as necessary to perform the acceptance tests. Arrangements shall be made to have tests witnessed by the COTR.

C. Visual Inspection:

1. Inspect exposed sections of cables for physical damage.
2. Inspect shield grounding, cable supports, splices, and terminations.
3. Verify that visible cable bends meet manufacturer's minimum bending radius requirement.
4. Verify installation of fireproofing tape and identification tags.

D. Electrical Tests:

1. Acceptance tests shall be performed on new and service-aged cables as specified herein.
2. Test new cable after installation, splices, and terminations have been made, but before connection to equipment and existing cable.

E. Service-Aged Cable Tests:

1. Maintenance tests shall be performed on service-aged cable interconnected to new cable.
2. After new cable test and connection to an existing cable, test the interconnected cable. Disconnect cable from all equipment that could be damaged by the test.

F. Insulation-Resistance Test: Test all new and service-aged cables with respect to ground and adjacent conductors.

1. Test data shall include megohm readings and leakage current readings. Cables shall not be energized until insulation-resistance test results have been approved by the COTR. Test voltages and minimum acceptable resistance values shall be:

<u>Voltage Class</u>	<u>Test Voltage</u>	<u>Min. Insulation Resistance</u>
5kV	2,500 VDC	1,000 megohms
15kV	2,500 VDC	5,000 megohms
25kV	5,000 VDC	20,000 megohms
35kV	15,000 VDC	100,000 megohms

2. Submit a field test report to the COTR that describes the identification and location of cables tested, the test equipment used, and the date tests were performed; identifies the persons who performed the tests; and identifies the insulation resistance and leakage current results for each cable section tested. The report shall provide conclusions and recommendations for corrective action.

G. Online Partial Discharge Test: Comply with IEEE 400 and 400.3. Test all new and service-aged cables. Perform tests after cables have passed the insulation-resistance test, and after successful energization.

1. Testing shall use a time or frequency domain detection process, incorporating radio frequency current transformer sensors with a partial discharge detection range of 10 kHz to 300 MHz.
 2. Submit a field test report to the COTR that describes the identification and location of cables tested, the test equipment used, and the date tests were performed; identifies the persons who performed the tests; and numerically and graphically identifies the magnitude of partial discharge detected for each cable section tested. The report shall provide conclusions and recommendations for corrective action.
- H. Final Acceptance: Final acceptance shall depend upon the satisfactory performance of the cables under test. No cable shall be put into service until all tests are successfully passed, and field test reports have been approved by the COTR.

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

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of the electrical conductors and cables for use in electrical systems rated 600 V and below, indicated as cable(s), conductor(s), wire, or wiring in this section.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire-resistant rated construction.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for conductors and cables.
- E. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Installation of conductors and cables in manholes and ducts.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Conductors and cables shall be thoroughly tested at the factory per NEMA to ensure that there are no electrical defects. Factory tests shall be certified.

1.5 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit the following data for approval:
 - 1) Electrical ratings and insulation type for each conductor and cable.
 - 2) Splicing materials and pulling lubricant.

2. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the conductors and cables conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the conductors and cables have been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are reference in the text by designation only.
- B. American Society of Testing Material (ASTM):
 - D2301-10 Standard Specification for Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape
 - D2304-10 Test Method for Thermal Endurance of Rigid Electrical Insulating Materials
 - D3005-10 Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape
- C. National Electrical Manufacturers Association (NEMA):
 - WC 70-09 Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
- D. National Fire Protection Association (NFPA):
 - 70-11 National Electrical Code (NEC)
- E. Underwriters Laboratories, Inc. (UL):
 - 44-10 Thermoset-Insulated Wires and Cables
 - 83-08 Thermoplastic-Insulated Wires and Cables
 - 467-07 Grounding and Bonding Equipment
 - 486A-486B-03 Wire Connectors
 - 486C-04 Splicing Wire Connectors
 - 486D-05 Sealed Wire Connector Systems
 - 486E-09 Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
 - 493-07 Thermoplastic-Insulated Underground Feeder and Branch Circuit Cables
 - 514B-04 Conduit, Tubing, and Cable Fittings

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Conductors and cables shall be in accordance with NEMA, UL, as specified herein, and as shown on the drawings.
- B. All conductors shall be copper.
- C. Single Conductor and Cable:
 - 1. No. 12 AWG: Minimum size, except where smaller sizes are specified herein or shown on the drawings.
 - 2. No. 8 AWG and larger: Stranded.
 - 3. No. 10 AWG and smaller: Solid; except shall be stranded for final connection to motors, transformers, and vibrating equipment.
 - 4. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.
- E. Color Code:
 - 1. No. 10 AWG and smaller: Solid color insulation or solid color coating.
 - 2. No. 8 AWG and larger: Color-coded using one of the following methods:
 - a. Solid color insulation or solid color coating.
 - b. Stripes, bands, or hash marks of color specified.
 - c. Color using 19 mm (0.75 inches) wide tape.
 - 4. For modifications and additions to existing wiring systems, color coding shall conform to the existing wiring system.
 - 5. Conductors shall be color-coded as follows:

208/120 V	Phase	480/277 V
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray *
* or white with colored (other than green) tracer.		

- 6. Lighting circuit “switch legs”, and 3-way and 4-way switch “traveling wires,” shall have color coding that is unique and distinct (e.g., pink and purple) from the color coding indicated above. The unique color codes shall be solid and in accordance with the NEC. Coordinate color coding in the field with the COTR.

7. Color code for isolated power system wiring shall be in accordance with the NEC.

2.2 SPLICES

- A. Splices shall be in accordance with NEC and UL.
- B. Above Ground Splices for No. 10 AWG and Smaller:
 1. Solderless, screw-on, reusable pressure cable type, with integral insulation, approved for copper and aluminum conductors.
 2. The integral insulator shall have a skirt to completely cover the stripped conductors.
 3. The number, size, and combination of conductors used with the connector, as listed on the manufacturer's packaging, shall be strictly followed.
- C. Above Ground Splices for No. 8 AWG to No. 4/0 AWG:
 1. Compression, hex screw, or bolt clamp-type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.
 2. Insulate with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than the insulation level of the conductors being joined.
 3. Splice and insulation shall be product of the same manufacturer.
 4. All bolts, nuts, and washers used with splices shall be zinc-plated steel.
- D. Above Ground Splices for 250 kcmil and Larger:
 1. Long barrel "butt-splice" or "sleeve" type compression connectors, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.
 2. Insulate with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than the insulation level of the conductors being joined.
 3. Splice and insulation shall be product of the same manufacturer.
- G. Plastic electrical insulating tape: Per ASTM D2304, flame-retardant, cold and weather resistant.

2.3 CONNECTORS AND TERMINATIONS

- A. Mechanical type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.
- B. Long barrel compression type of high conductivity and corrosion-resistant material, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.

- C. All bolts, nuts, and washers used to connect connections and terminations to bus bars or other termination points shall be zinc-plated steel.

2.4 CONTROL WIRING

- A. Unless otherwise specified elsewhere in these specifications, control wiring shall be as specified herein, except that the minimum size shall be not less than No. 14 AWG.
- B. Control wiring shall be sized such that the voltage drop under in-rush conditions does not adversely affect operation of the controls.

2.5 WIRE LUBRICATING COMPOUND

- A. Lubricating compound shall be suitable for the wire insulation and conduit, and shall not harden or become adhesive.
- B. Shall not be used on conductors for isolated power systems.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install conductors in accordance with the NEC, as specified, and as shown on the drawings.
- B. Install all conductors in raceway systems.
- C. Splice conductors only in outlet boxes, junction boxes, pullboxes, manholes, or handholes.
- D. Conductors of different systems (e.g., 120 V and 277 V) shall not be installed in the same raceway.
- E. Install cable supports for all vertical feeders in accordance with the NEC. Provide split wedge type which firmly clamps each individual cable and tightens due to cable weight.
- F. In panelboards, cabinets, wireways, switches, enclosures, and equipment assemblies, neatly form, train, and tie the conductors with non-metallic ties.
- G. For connections to motors, transformers, and vibrating equipment, stranded conductors shall be used only from the last fixed point of connection to the motors, transformers, or vibrating equipment.
- H. Use expanding foam or non-hardening duct-seal to seal conduits entering a building, after installation of conductors.
- I. Conductor and Cable Pulling:
 - 1. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling. Use lubricants approved for the cable.
 - 2. Use nonmetallic pull ropes.

3. Attach pull ropes by means of either woven basket grips or pulling eyes attached directly to the conductors.
 4. All conductors in a single conduit shall be pulled simultaneously.
 5. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- J. No more than three branch circuits shall be installed in any one conduit.
- K. When stripping stranded conductors, use a tool that does not damage the conductor or remove conductor strands.

3.2 INSTALLATION IN MANHOLES

- A. Train the cables around the manhole walls, but do not bend to a radius less than six times the overall cable diameter.

3.3 SPLICE AND TERMINATION INSTALLATION

- A. Splices and terminations shall be mechanically and electrically secure, and tightened to manufacturer's published torque values using a torque screwdriver or wrench.
- B. Where the Government determines that unsatisfactory splices or terminations have been installed, replace the splices or terminations at no additional cost to the Government.

3.4 CONDUCTOR IDENTIFICATION

- A. When using colored tape to identify phase, neutral, and ground conductors larger than No. 8 AWG, apply tape in half-overlapping turns for a minimum of 75 mm (3 inches) from terminal points, and in junction boxes, pullboxes, and manholes. Apply the last two laps of tape with no tension to prevent possible unwinding. Where cable markings are covered by tape, apply tags to cable, stating size and insulation type.

3.5 FEEDER CONDUCTOR IDENTIFICATION

- A. In each interior pullbox and each underground manhole and handhole, install brass tags on all feeder conductors to clearly designate their circuit identification and voltage. The tags shall be the embossed type, 40 mm (1-1/2 inches) in diameter and 40 mils thick. Attach tags with plastic ties.

3.6 EXISTING CONDUCTORS

- A. Unless specifically indicated on the plans, existing conductors shall not be reused.

3.7 CONTROL WIRING INSTALLATION

- A. Unless otherwise specified in other sections, install control wiring and connect to equipment to perform the required functions as specified or as shown on the drawings.

- B. Install a separate power supply circuit for each system, except where otherwise shown on the drawings.

3.8 CONTROL WIRING IDENTIFICATION

- A. Install a permanent wire marker on each wire at each termination.
- B. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.
- C. Wire markers shall retain their markings after cleaning.
- D. In each manhole and handhole, install embossed brass tags to identify the system served and function.

3.10 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests: Inspect physical condition.
 - 2. Electrical tests:
 - a. After installation but before connection to utilization devices, such as fixtures, motors, or appliances, test conductors phase-to-phase and phase-to-ground resistance with an insulation resistance tester. Existing conductors to be reused shall also be tested.
 - b. Applied voltage shall be 500 V DC for 300 V rated cable, and 1000 V DC for 600 V rated cable. Apply test for one minute or until reading is constant for 15 seconds, whichever is longer. Minimum insulation resistance values shall not be less than 25 megohms for 300 V rated cable and 100 megohms for 600 V rated cable.
 - c. Perform phase rotation test on all three-phase circuits.

---END---

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of grounding and bonding equipment, indicated as grounding equipment in this section.
- B. "Grounding electrode system" refers to grounding electrode conductors and all electrodes required or allowed by NEC, as well as made, supplementary, and lightning protection system grounding electrodes.
- C. The terms "connect" and "bond" are used interchangeably in this section and have the same meaning.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit and boxes.
- D. Section 26 12 19, PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS: pad-mounted, liquid-filled, medium-voltage transformers.
- E. Section 26 13 16, MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES: Medium-voltage fusible interrupter switches.
- F. Section 26 22 00, LOW-VOLTAGE TRANSFORMERS: Low-voltage transformers.
- G. Section 26 24 16, PANELBOARDS: Low-voltage panelboards.
- H. Section 26 41 00, FACILITY LIGHTNING PROTECTION: Lightning protection.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.

- b. Submit plans showing the location of system grounding electrodes and connections, and the routing of aboveground and underground grounding electrode conductors.
- 2. Test Reports:
 - a. Two weeks prior to the final inspection, submit ground resistance field test reports to the COTR.
- 3. Certifications:
 - a. Certification by the Contractor that the grounding equipment has been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American Society for Testing and Materials (ASTM):
 - B1-07 Standard Specification for Hard-Drawn Copper Wire
 - B3-07 Standard Specification for Soft or Annealed Copper Wire
 - B8-11 Standard Specification for Concentric-Lay-Stranded
Copper Conductors, Hard, Medium-Hard, or Soft
- C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 81-83..... IEEE Guide for Measuring Earth Resistivity, Ground
Impedance, and Earth Surface Potentials of a Ground
System Part 1: Normal Measurements
- D. National Fire Protection Association (NFPA):
 - 70-11 National Electrical Code (NEC)
 - 70E-12..... National Electrical Safety Code
 - 99-12..... Health Care Facilities
- E. Underwriters Laboratories, Inc. (UL):
 - 44-10 Thermoset-Insulated Wires and Cables
 - 83-08 Thermoplastic-Insulated Wires and Cables
 - 467-07 Grounding and Bonding Equipment

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

- A. Equipment grounding conductors shall be insulated stranded copper, except that sizes No. 10 AWG and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes No. 4 AWG and larger shall be identified per NEC.
- B. Bonding conductors shall be bare stranded copper, except that sizes No. 10 AWG and smaller shall be bare solid copper. Bonding conductors shall be stranded for final connection to motors, transformers, and vibrating equipment.
- C. Conductor sizes shall not be less than shown on the drawings, or not less than required by the NEC, whichever is greater.
- D. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.

2.2 GROUND RODS

- A. Steel or copper clad steel, 19 mm (0.75 inch) diameter by 3 M (10 feet) long.
- B. Quantity of rods shall be as shown on the drawings, and as required to obtain the specified ground resistance.

2.3 CONCRETE ENCASED ELECTRODE

- A. Concrete encased electrode shall be No. 4 AWG bare copper wire, installed per NEC.

2.4 GROUND CONNECTIONS

- A. Below Grade and Inaccessible Locations: Exothermic-welded type connectors.
- B. Above Grade:
 - 1. Bonding Jumpers: Listed for use with aluminum and copper conductors. For wire sizes No. 8 AWG and larger, use compression-type connectors. For wire sizes smaller than No. 8 AWG, use mechanical type lugs. Connectors or lugs shall use zinc-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.
 - 2. Connection to Building Steel: Exothermic-welded type connectors.
 - 3. Connection to Grounding Bus Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with zinc-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.
 - 4. Connection to Equipment Rack and Cabinet Ground Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with zinc-plated steel

bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2.5 EQUIPMENT RACK AND CABINET GROUND BARS

- A. Provide solid copper ground bars designed for mounting on the framework of open or cabinet-enclosed equipment racks. Ground bars shall have minimum dimensions of 6.3 mm (0.25 inch) thick x 19 mm (0.75 inch) wide, with length as required or as shown on the drawings. Provide insulators and mounting brackets.

2.6 GROUND TERMINAL BLOCKS

- A. At any equipment mounting location (e.g., backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide mechanical type lugs, with zinc-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2.7 GROUNDING BUS BAR

- A. Pre-drilled rectangular copper bar with stand-off insulators, minimum 6.3 mm (0.25 inch) thick x 100 mm (4 inches) high in cross-section, length as shown on the drawings, with hole size, quantity, and spacing per detail shown on the drawings. Provide insulators and mounting brackets.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install grounding equipment in accordance with the NEC, as shown on the drawings, and as specified herein.
- B. System Grounding:
 - 1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformer.
 - 2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.
- C. Equipment Grounding: Metallic piping, building structural steel, electrical enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits, shall be bonded and grounded.

3.2 INACCESSIBLE GROUNDING CONNECTIONS

- A. Make grounding connections, which are normally buried or otherwise inaccessible, by exothermic weld.

3.3 MEDIUM-VOLTAGE EQUIPMENT AND CIRCUITS

- A. Switchgear: Provide a bare grounding electrode conductor from the switchgear ground bus to the grounding electrode system.
- B. Duct Banks and Manholes: Provide an insulated equipment grounding conductor in each duct containing medium-voltage conductors, sized per NEC except that minimum size shall be No. 2 AWG. Bond the equipment grounding conductors to the switchgear ground bus, to all manhole grounding provisions and hardware, to the cable shield grounding provisions of medium-voltage cable splices and terminations, and to equipment enclosures.
- C. Pad-Mounted Transformers:
 - 1. Provide a driven ground rod and bond with a grounding electrode conductor to the transformer grounding pad.
 - 2. Ground the secondary neutral.
- D. Lightning Arresters: Connect lightning arresters to the equipment ground bus or ground rods as applicable.

3.4 SECONDARY VOLTAGE EQUIPMENT AND CIRCUITS

- A. Main Bonding Jumper: Bond the secondary service neutral to the ground bus in the service equipment.
- B. Metallic Piping, Building Structural Steel, and Supplemental Electrode(s):
 - 1. Provide a grounding electrode conductor sized per NEC between the service equipment ground bus and all metallic water pipe systems, building structural steel, and supplemental or made electrodes. Provide jumpers across insulating joints in the metallic piping.
 - 2. Provide a supplemental ground electrode as shown on the drawings and bond to the grounding electrode system.
- C. Panelboards, and other electrical equipment:
 - 1. Connect the equipment grounding conductors to the ground bus.
 - 2. Connect metallic conduits by grounding bushings and equipment grounding conductor to the equipment ground bus.
- D. Transformers:
 - 1. Exterior: Exterior transformers supplying interior service equipment shall have the neutral grounded at the transformer secondary. Provide a grounding electrode at the transformer.

2. Separately derived systems (transformers downstream from service equipment):
Ground the secondary neutral at the transformer. Provide a grounding electrode conductor from the transformer to the ground bar at the service equipment.

3.5 RACEWAY

A. Conduit Systems:

1. Ground all metallic conduit systems. All metallic conduit systems shall contain an equipment grounding conductor.
2. Non-metallic conduit systems, except non-metallic feeder conduits that carry a grounded conductor from exterior transformers to interior or building-mounted service entrance equipment, shall contain an equipment grounding conductor.
3. Metallic conduit that only contains a grounding conductor, and is provided for its mechanical protection, shall be bonded to that conductor at the entrance and exit from the conduit.
4. Metallic conduits which terminate without mechanical connection to an electrical equipment housing by means of locknut and bushings or adapters, shall be provided with grounding bushings. Connect bushings with a equipment grounding conductor to the equipment ground bus.

B. Feeders and Branch Circuits: Install equipment grounding conductors with all feeders, and power and lighting branch circuits.

C. Boxes, Cabinets, Enclosures, and Panelboards:

1. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes (except for special grounding systems for intensive care units and other critical units shown).
2. Provide lugs in each box and enclosure for equipment grounding conductor termination.

D. Wireway Systems:

1. Bond the metallic structures of wireway to provide electrical continuity throughout the wireway system, by connecting a No. 6 AWG bonding jumper at all intermediate metallic enclosures and across all section junctions.
2. Install insulated No. 6 AWG bonding jumpers between the wireway system, bonded as required above, and the closest building ground at each end and approximately every 16 M (50 feet).

3. Use insulated No. 6 AWG bonding jumpers to ground or bond metallic wireway at each end for all intermediate metallic enclosures and across all section junctions.
4. Use insulated No. 6 AWG bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 15 M (49 feet).
- E. Receptacles shall not be grounded through their mounting screws. Ground receptacles with a jumper from the receptacle green ground terminal to the device box ground screw and a jumper to the branch circuit equipment grounding conductor.
- F. Ground lighting fixtures to the equipment grounding conductor of the wiring system. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.
- G. Fixed electrical appliances and equipment shall be provided with a ground lug for termination of the equipment grounding conductor.

3.6 OUTDOOR METALLIC FENCES AROUND ELECTRICAL EQUIPMENT

- A. Fences shall be grounded with a ground rod at each fixed gate post and at each corner post.
- B. Drive ground rods until the top is 300 mm (12 inches) below grade. Attach a No. 4 AWG copper conductor by exothermic weld to the ground rods, and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 300 mm (12 inches) of fence mesh and fasten by two approved bronze compression fittings, one to bond the wire to post and the other to bond the wire to fence. Each gate section shall be bonded to its gatepost by a 3 mm x 25 mm (0.375 inch x 1 inch) flexible, braided copper strap and ground post clamps. Clamps shall be of the anti-electrolysis type.

3.7 CORROSION INHIBITORS

- A. When making grounding and bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.8 CONDUCTIVE PIPING

- A. Bond all conductive piping systems, interior and exterior, to the grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.

3.9 LIGHTNING PROTECTION SYSTEM

- A. Bond the lightning protection system to the electrical grounding electrode system.

3.10 MAIN ELECTRICAL ROOM GROUNDING

- A. Provide ground bus bar and mounting hardware at each main electrical room where incoming feeders are terminated, as shown on the drawings. Connect to pigtail extensions of the building grounding ring, as shown on the drawings.

3.12 GROUND RESISTANCE

- A. Grounding system resistance to ground shall not exceed 5 ohms. Make any modifications or additions to the grounding electrode system necessary for compliance without additional cost to the Government. Final tests shall ensure that this requirement is met.
- B. Grounding system resistance shall comply with the electric utility company ground resistance requirements.

3.13 GROUND ROD INSTALLATION

- A. For outdoor installations, drive each rod vertically in the earth, until top of rod is 610 mm (24 inches) below final grade.
- B. For indoor installations, leave 100 mm (4 inches) of each rod exposed.
- C. Where buried or permanently concealed ground connections are required, make the connections by the exothermic process, to form solid metal joints. Make accessible ground connections with mechanical pressure-type ground connectors.
- D. Where rock or impenetrable soil prevents the driving of vertical ground rods, install angled ground rods or grounding electrodes in horizontal trenches to achieve the specified ground resistance.

3.14 ACCEPTANCE CHECKS AND TESTS

- A. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized or connected to the electric utility company ground system, and shall be made in normally dry conditions not fewer than 48 hours after the last rainfall.
- B. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.
- C. Below-grade connections shall be visually inspected by the COTR prior to backfilling. The Contractor shall notify the COTR 24 hours before the connections are ready for inspection.

---END---

**SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of conduit, fittings, and boxes, to form complete, coordinated, grounded raceway systems. Raceways are required for all wiring unless shown or specified otherwise.
- B. Definitions: The term conduit, as used in this specification, shall mean any or all of the raceway types specified.

1.2 RELATED WORK

- A. Section 06 10 00, ROUGH CARPENTRY: Mounting board for telephone closets.
- B. Section 07 60 00, FLASHING AND SHEET METAL: Fabrications for the deflection of water away from the building envelope at penetrations.
- C. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire rated construction.
- D. Section 07 92 00, JOINT SEALANTS: Sealing around conduit penetrations through the building envelope to prevent moisture migration into the building.
- E. Section 09 91 00, PAINTING: Identification and painting of conduit and other devices.
- F. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Conduits bracing.
- G. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- H. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- I. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Underground conduits.
- J. Section 31 20 00, EARTHWORK: Bedding of conduits.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit six copies of the following in accordance with Section 26 05 11,
REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1. Shop Drawings:

- a. Size and location of main feeders.
- b. Size and location of panels and pull-boxes.
- c. Layout of required conduit penetrations through structural elements.
- d. Submit the following data for approval:

- 1) Raceway types and sizes.
- 2) Conduit bodies, connectors and fittings.
- 3) Junction and pull boxes, types and sizes.

2. Certifications: Two weeks prior to final inspection, submit the following:

- a. Certification by the manufacturer that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment conform to the requirements of the drawings and specifications.
- b. Certification by the Contractor that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment have been properly installed.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American National Standards Institute (ANSI):

- C80.1-05 Electrical Rigid Steel Conduit
- C80.3-05 Steel Electrical Metal Tubing
- C80.6-05 Electrical Intermediate Metal Conduit

C. National Fire Protection Association (NFPA):

- 70-11 National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (UL):

- 1-05 Flexible Metal Conduit
- 5-11 Surface Metal Raceway and Fittings
- 6-07 Electrical Rigid Metal Conduit - Steel
- 50-95 Enclosures for Electrical Equipment
- 360-13 Liquid-Tight Flexible Steel Conduit

- 467-13..... Grounding and Bonding Equipment
 - 514A-13..... Metallic Outlet Boxes
 - 514B-12..... Conduit, Tubing, and Cable Fittings
 - 514C-07 Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers
 - 651-11 Schedule 40 and 80 Rigid PVC Conduit and Fittings
 - 651A-11..... Type EB and A Rigid PVC Conduit and HDPE Conduit
 - 797-07 Electrical Metallic Tubing
 - 1242-06..... Electrical Intermediate Metal Conduit - Steel
- E. National Electrical Manufacturers Association (NEMA):
- TC-2-13..... Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
 - TC-3-13..... PVC Fittings for Use with Rigid PVC Conduit and Tubing
 - FB1-12 Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
 - FB2.10-13 Selection and Installation Guidelines for Fittings for use with Non-Flexible Conduit or Tubing (Rigid Metal Conduit, Intermediate Metallic Conduit, and Electrical Metallic Tubing)
 - FB2.20-12 Selection and Installation Guidelines for Fittings for use with Flexible Electrical Conduit and Cable
- F. American Iron and Steel Institute (AISI):
- S100-2007..... North American Specification for the Design of Cold-Formed Steel Structural Members

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Conduit Size: In accordance with the NEC, but not less than 13 mm (0.5-inch) unless otherwise shown. Where permitted by the NEC, 13 mm (0.5-inch) flexible conduit may be used for tap connections to recessed lighting fixtures.
- B. Conduit:
 - 1. Size: In accordance with the NEC, but not less than 13 mm (0.5-inch).
 - 2. Rigid Steel Conduit (RMC): Shall conform to UL 6 and ANSI C80.1.
 - 3. Rigid Intermediate Steel Conduit (IMC): Shall conform to UL 1242 and ANSI C80.6.
 - 4. Electrical Metallic Tubing (EMT): Shall conform to UL 797 and ANSI C80.3.
Maximum size not to exceed 105 mm (4 inches) and shall be permitted only with cable rated 600 V or less.

5. Flexible Metal Conduit: Shall conform to UL 1.
 6. Liquid-tight Flexible Metal Conduit: Shall conform to UL 360.
 7. Direct Burial Plastic Conduit: Shall conform to UL 651 and UL 651A, heavy wall PVC or high density polyethylene (PE).
 8. Surface Metal Raceway: Shall conform to UL 5.
- C. Conduit Fittings:
1. Rigid Steel and Intermediate Metallic Conduit Fittings:
 - a. Fittings shall meet the requirements of UL 514B and NEMA FB1.
 - b. Standard threaded couplings, locknuts, bushings, conduit bodies, and elbows: Only steel or malleable iron materials are acceptable. Integral retractable type IMC couplings are also acceptable.
 - c. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.
 - d. Bushings: Metallic insulating type, consisting of an insulating insert, molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted.
 - e. Erickson (Union-Type) and Set Screw Type Couplings: Approved for use in concrete are permitted for use to complete a conduit run where conduit is installed in concrete. Use set screws of case-hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.
 - f. Sealing Fittings: Threaded cast iron type. Use continuous drain-type sealing fittings to prevent passage of water vapor. In concealed work, install fittings in flush steel boxes with blank cover plates having the same finishes as that of other electrical plates in the room.
 3. Electrical Metallic Tubing Fittings:
 - a. Fittings and conduit bodies shall meet the requirements of UL 514B, ANSI C80.3, and NEMA FB1.
 - b. Only steel or malleable iron materials are acceptable.
 - c. Indent-type connectors or couplings are prohibited.
 - d. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are prohibited.
 4. Flexible Metal Conduit Fittings:
 - a. Conform to UL 514B. Only steel or malleable iron materials are acceptable.

- b. Clamp-type, with insulated throat.
- 5. Liquid-tight Flexible Metal Conduit Fittings:
 - a. Fittings shall meet the requirements of UL 514B and NEMA FB1.
 - b. Only steel or malleable iron materials are acceptable.
 - c. Fittings must incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening. Connectors shall have insulated throats.
- 6. Direct Burial Plastic Conduit Fittings: Fittings shall meet the requirements of UL 514C and NEMA TC3.
- 7. Surface Metal Raceway Fittings: As recommended by the raceway manufacturer. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, conduit entry fittings, accessories, and other fittings as required for complete system.
- 8. Expansion and Deflection Couplings:
 - a. Conform to UL 467 and UL 514B.
 - b. Accommodate a 19 mm (0.75-inch) deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.
 - c. Include internal flexible metal braid, sized to guarantee conduit ground continuity and a low-impedance path for fault currents, in accordance with UL 467 and the NEC tables for equipment grounding conductors.
 - d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat-resistant molded rubber material with stainless steel jacket clamps.
- D. Conduit Supports:
 - 1. Parts and Hardware: Zinc-coat or provide equivalent corrosion protection.
 - 2. Individual Conduit Hangers: Designed for the purpose, having a pre-assembled closure bolt and nut, and provisions for receiving a hanger rod.
 - 3. Multiple Conduit (Trapeze) Hangers: Not less than 38 mm x 38 mm (1.5 x 1.5 inches), 12-gauge steel, cold-formed, lipped channels; with not less than 9 mm (0.375-inch) diameter steel hanger rods.
 - 4. Solid Masonry and Concrete Anchors: Self-drilling expansion shields, or machine bolt expansion.
- E. Outlet, Junction, and Pull Boxes:
 - 1. UL-50 and UL-514A.
 - 2. Rustproof cast metal where required by the NEC or shown on drawings.

3. Sheet Metal Boxes: Galvanized steel, except where shown on drawings.
- F. Metal Wireways: Equip with hinged covers, except as shown on drawings. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.

PART 3 - EXECUTION

3.1 PENETRATIONS

- A. Cutting or Holes:
 1. Cut holes in advance where they should be placed in the structural elements, such as ribs or beams. Obtain the approval of the COTR prior to drilling through structural elements.
 2. Cut holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammers, impact electric, hand, or manual hammer-type drills are not allowed, except when permitted by the COTR where working space is limited.
- B. Firestop: Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING.
- C. Waterproofing: At floor, exterior wall, and roof conduit penetrations, completely seal the gap around conduit to render it watertight, as specified in Section 07 92 00, JOINT SEALANTS.

3.2 INSTALLATION, GENERAL

- A. In accordance with UL, NEC, NEMA, as shown on drawings, and as specified herein.
- B. Raceway systems used for Essential Electrical Systems (EES) shall be entirely independent of other raceway systems.
- C. Install conduit as follows:
 1. In complete mechanically and electrically continuous runs before pulling in cables or wires.
 2. Unless otherwise indicated on the drawings or specified herein, installation of all conduits shall be concealed within finished walls, floors, and ceilings.
 3. Flattened, dented, or deformed conduit is not permitted. Remove and replace the damaged conduits with new conduits.
 4. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.

5. Cut conduits square, ream, remove burrs, and draw up tight.
 6. Independently support conduit at 2.4 M (8 feet) on centers with specified materials and as shown on drawings.
 7. Do not use suspended ceilings, suspended ceiling supporting members, lighting fixtures, other conduits, cable tray, boxes, piping, or ducts to support conduits and conduit runs.
 8. Support within 300 mm (12 inches) of changes of direction, and within 300 mm (12 inches) of each enclosure to which connected.
 9. Close ends of empty conduits with plugs or caps at the rough-in stage until wires are pulled in, to prevent entry of debris.
 10. Conduit installations under fume and vent hoods are prohibited.
 11. Secure conduits to cabinets, junction boxes, pull-boxes, and outlet boxes with bonding type locknuts. For rigid steel and IMC conduit installations, provide a locknut on the inside of the enclosure, made up wrench tight. Do not make conduit connections to junction box covers.
 12. Flashing of penetrations of the roof membrane is specified in Section 07 60 00, FLASHING AND SHEET METAL.
 13. Conduit bodies shall only be used for changes in direction, and shall not contain splices.
- D. Conduit Bends:
1. Make bends with standard conduit bending machines.
 2. Conduit hickey may be used for slight offsets and for straightening stubbed out conduits.
 3. Bending of conduits with a pipe tee or vise is prohibited.
- E. Layout and Homeruns:
1. Install conduit with wiring, including homeruns, as shown on drawings.
 2. Deviations: Make only where necessary to avoid interferences and only after drawings showing the proposed deviations have been submitted and approved by the COTR.

3.3 CONCEALED WORK INSTALLATION

- A. In Concrete:
1. Conduit: Rigid steel, IMC, or EMT. Do not install EMT in concrete slabs that are in contact with soil, gravel, or vapor barriers.
 2. Align and run conduit in direct lines.

3. Install conduit through concrete beams only:
 - a. Where shown on the structural drawings.
 - b. As approved by the COTR prior to construction, and after submittal of drawing showing location, size, and position of each penetration.
 4. Installation of conduit in concrete that is less than 75 mm (3 inches) thick is prohibited.
 - a. Conduit outside diameter larger than one-third of the slab thickness is prohibited.
 - b. Space between conduits in slabs: Approximately six conduit diameters apart, and one conduit diameter at conduit crossings.
 - c. Install conduits approximately in the center of the slab so that there will be a minimum of 19 mm (0.75-inch) of concrete around the conduits.
 5. Make couplings and connections watertight. Use thread compounds that are UL approved conductive type to ensure low resistance ground continuity through the conduits. Tightening setscrews with pliers is prohibited.
- B. Above Furred or Suspended Ceilings and in Walls:
1. Conduit for Conductors Above 600 V: Rigid steel. Mixing different types of conduits in the same system is prohibited.
 2. Conduit for Conductors 600 V and Below: Rigid steel, IMC, or EMT. Mixing different types of conduits in the same system is prohibited.
 3. Align and run conduit parallel or perpendicular to the building lines.
 4. Connect recessed lighting fixtures to conduit runs with maximum 1.8 M (6 feet) of flexible metal conduit extending from a junction box to the fixture.
 5. Tightening set screws with pliers is prohibited.
 6. For conduits running through metal studs, limit field cut holes to no more than 70% of web depth. Spacing between holes shall be at least 457 mm (18 inches). Cuts or notches in flanges or return lips shall not be permitted.

3.4 EXPOSED WORK INSTALLATION

- A. Unless otherwise indicated on drawings, exposed conduit is only permitted in mechanical and electrical rooms.
- B. Conduit for Conductors Above 600 V: Rigid steel. Mixing different types of conduits in the system is prohibited.
- C. Conduit for Conductors 600 V and Below: Rigid steel, IMC, or EMT. Mixing different types of conduits in the system is prohibited.
- D. Align and run conduit parallel or perpendicular to the building lines.

- E. Install horizontal runs close to the ceiling or beams and secure with conduit straps.
- F. Support horizontal or vertical runs at not over 2.4 M (8 feet) intervals.
- G. Surface Metal Raceways: Use only where shown on drawings.
- H. Painting:
 - 1. Paint exposed conduit as specified in Section 09 91 00, PAINTING.
 - 2. Paint all conduits containing cables rated over 600 V safety orange. Refer to Section 09 91 00, PAINTING for preparation, paint type, and exact color. In addition, paint legends, using 50 mm (2 inch) high black numerals and letters, showing the cable voltage rating. Provide legends where conduits pass through walls and floors and at maximum 6 M (20 feet) intervals in between.

3.5 DIRECT BURIAL INSTALLATION

Refer to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

3.6 HAZARDOUS LOCATIONS

- A. Use rigid steel conduit only.
- B. Install UL approved sealing fittings that prevent passage of explosive vapors in hazardous areas equipped with explosion-proof lighting fixtures, switches, and receptacles, as required by the NEC.

3.7 WET OR DAMP LOCATIONS

- A. Use rigid steel or IMC conduits unless as shown on drawings.
- B. Provide sealing fittings to prevent passage of water vapor where conduits pass from warm to cold locations, i.e., refrigerated spaces, constant-temperature rooms, air-conditioned spaces, building exterior walls, roofs, or similar spaces.
- C. Use rigid steel or IMC conduit within 1.5 M (5 feet) of the exterior and below concrete building slabs in contact with soil, gravel, or vapor barriers, unless as shown on drawings. Conduit shall be half-lapped with 10 mil PVC tape before installation. After installation, completely recoat or retape any damaged areas of coating.
- D. Conduits run on roof shall be supported with integral galvanized lipped steel channel, attached to UV-inhibited polycarbonate or polypropylene blocks every 2.4 M (8 feet) with 9 mm (3/8-inch) galvanized threaded rods, square washer and locknut. Conduits shall be attached to steel channel with conduit clamps.

3.8 MOTORS AND VIBRATING EQUIPMENT

- A. Use flexible metal conduit for connections to motors and other electrical equipment subject to movement, vibration, misalignment, cramped quarters, or noise transmission.

- B. Use liquid-tight flexible metal conduit for installation in exterior locations, moisture or humidity laden atmosphere, corrosive atmosphere, water or spray wash-down operations, inside airstream of HVAC units, and locations subject to seepage or dripping of oil, grease, or water.
- C. Provide a green equipment grounding conductor with flexible and liquid-tight flexible metal conduit.

3.9 EXPANSION JOINTS

- A. Conduits 75 mm (3 inch) and larger that are secured to the building structure on opposite sides of a building expansion joint require expansion and deflection couplings. Install the couplings in accordance with the manufacturer's recommendations.
- B. Provide conduits smaller than 75 mm (3 inch) with junction boxes on both sides of the expansion joint. Connect flexible metal conduits to junction boxes with sufficient slack to produce a 125 mm (5 inch) vertical drop midway between the ends of the flexible metal conduit. Flexible metal conduit shall have a green insulated copper bonding jumper installed. In lieu of this flexible metal conduit, expansion and deflection couplings as specified above are acceptable.
- C. Install expansion and deflection couplings where shown.

3.10 CONDUIT SUPPORTS

- A. Safe working load shall not exceed one-quarter of proof test load of fastening devices.
- B. Use pipe straps or individual conduit hangers for supporting individual conduits.
- C. Support multiple conduit runs with trapeze hangers. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the conduits, wires, hanger itself, and an additional 90 kg (200 lbs). Attach each conduit with U-bolts or other approved fasteners.
- D. Support conduit independently of junction boxes, pull-boxes, fixtures, suspended ceiling T-bars, angle supports, and similar items.
- E. Fasteners and Supports in Solid Masonry and Concrete:
 - 1. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing the concrete.
 - 2. Existing Construction:
 - a. Steel expansion anchors not less than 6 mm (0.25-inch) bolt size and not less than 28 mm (1.125 inch) in embedment.
 - b. Power set fasteners not less than 6 mm (0.25-inch) diameter with depth of penetration not less than 75 mm (3 inch).

- c. Use vibration and shock-resistant anchors and fasteners for attaching to concrete ceilings.
- F. Hollow Masonry: Toggle bolts.
- G. Bolts supported only by plaster or gypsum wallboard are not acceptable.
- H. Metal Structures: Use machine screw fasteners or other devices specifically designed and approved for the application.
- I. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.
- J. Chain, wire, or perforated strap shall not be used to support or fasten conduit.
- K. Spring steel type supports or fasteners are prohibited for all uses except horizontal and vertical supports/fasteners within walls.
- L. Vertical Supports: Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

3.11 BOX INSTALLATION

- A. Boxes for Concealed Conduits:
 - 1. Flush-mounted.
 - 2. Provide raised covers for boxes to suit the wall or ceiling, construction, and finish.
- B. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling-in operations or where more than the equivalent of 4-90 degree bends are necessary.
- C. Locate pullboxes so that covers are accessible and easily removed. Coordinate locations with piping and ductwork where installed above ceilings.
- D. Remove only knockouts as required. Plug unused openings. Use threaded plugs for cast metal boxes and snap-in metal covers for sheet metal boxes.
- E. Outlet boxes mounted back-to-back in the same wall are prohibited. A minimum 600 mm (24 inch) center-to-center lateral spacing shall be maintained between boxes.
- F. Flush-mounted wall or ceiling boxes shall be installed with raised covers so that the front face of raised cover is flush with the wall. Surface-mounted wall or ceiling boxes shall be installed with surface-style flat or raised covers.
- G. Minimum size of outlet boxes for ground fault circuit interrupter (GFCI) receptacles is 100 mm (4 inches) square x 55 mm (2.125 inches) deep, with device covers for the wall material and thickness involved.

- H. Stencil or install phenolic nameplates on covers of the boxes identified on riser diagrams; for example "SIG-FA JB No. 1."
- I. On all branch circuit junction box covers, identify the circuits with black marker.

- - - E N D - - -

SECTION 26 05 41 UNDERGROUND ELECTRICAL CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of underground ducts and raceways, and precast manholes and pullboxes to form a complete underground electrical raceway system.
- B. The terms “duct” and “conduit” are used interchangeably in this section.

1.2 RELATED WORK

- A. Section 07 92 00, JOINT SEALANTS: Sealing of conduit penetrations.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 31 20 00, EARTH MOVING: Trenching, backfill, and compaction.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Coordinate layout and installation of ducts, manholes, and pullboxes with final arrangement of other utilities, site grading, and surface features.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit information on manholes, pullboxes, ducts, and hardware. Submit manhole plan and elevation drawings, showing openings, pulling irons, cable supports, cover, ladder, sump, and other accessories.
 - c. Proposed deviations from the drawings shall be clearly marked on the submittals. If it is necessary to locate manholes, pullboxes, or duct banks at locations other than shown on the drawings, show the proposed locations accurately on scaled site drawings, and submit to the COTR for approval prior to construction.

2. Certifications: Two weeks prior to the final inspection, submit the following.
 - a. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the materials have been properly installed, connected, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American Concrete Institute (ACI):
 - Building Code Requirements for Structural Concrete
 - 318-11/318M-11 Building Code Requirements for Structural Concrete & Commentary
 - SP-66-04 ACI Detailing Manual
- C. American National Standards Institute (ANSI):
 - 77-10 Underground Enclosure Integrity
- D. American Society for Testing and Materials (ASTM):
 - C478-12 Standard Specification for Precast Reinforced Concrete Manhole Sections
 - C858-10e1 Underground Precast Concrete Utility Structures
 - C990-09 Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants.
- E. National Electrical Manufacturers Association (NEMA):
 - TC 2-03 Electrical Polyvinyl Chloride (PVC) Conduit
 - TC 3-04 Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit And Tubing
 - TC 6 & 8-03 Polyvinyl Chloride (PVC) Plastic Utilities Duct For Underground Installations
 - TC 9-04 Fittings For Polyvinyl Chloride (PVC) Plastic Utilities Duct For Underground Installation
- F. National Fire Protection Association (NFPA):
 - 70-11 National Electrical Code (NEC)
 - 70E-12 National Electrical Safety Code
- G. Underwriters Laboratories, Inc. (UL):

6-07	Electrical Rigid Metal Conduit-Steel
467-07	Grounding and Bonding Equipment
651-11	Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
651A-11.....	Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit
651B-07.....	Continuous Length HDPE Conduit

PART 2 - PRODUCTS

2.1 PRE-CAST CONCRETE MANHOLES AND HARDWARE

- A. Structure: Factory-fabricated, reinforced-concrete, monolithically-poured walls and bottom. Frame and cover shall form top of manhole.
- B. Cable Supports:
 - 1. Cable stanchions shall be hot-rolled, heavy duty, hot-dipped galvanized "T" section steel, 56 mm (2.25 inches) x 6 mm (0.25 inch) in size, and punched with 14 holes on 38 mm (1.5 inches) centers for attaching cable arms.
 - 2. Cable arms shall be 5 mm (0.1875 inch) gauge, hot-rolled, hot-dipped galvanized sheet steel, pressed to channel shape. Arms shall be approximately 63 mm (2.5 inches) wide x 350 mm (14 inches) long.
 - 3. Insulators for cable supports shall be porcelain, and shall be saddle type or type that completely encircles the cable.
 - 4. Equip each cable stanchion with one spare cable arm, with three spare insulators for future use.
- C. Ladder: Fiberglass with 400 mm (16 inches) rung spacing. Provide securely-mounted ladder for every manhole over 1.2 M (4 feet) deep.
- D. Ground Rod Sleeve: Provide a 75 mm (3 inches) PVC sleeve in manhole floors so that a driven ground rod may be installed.
- E. Sump: Provide 305 mm x 305 mm (12 inches x 12 inches) covered sump frame and grated cover.

2.2 PULLBOXES

- A. General: Size as indicated on the drawings. Provide pullboxes with weatherproof, non-skid covers with recessed hook eyes, secured with corrosion- and tamper-resistant hardware. Cover material shall be identical to pullbox material. Covers shall have molded lettering, ELECTRIC or SIGNAL as applicable. Pullboxes shall comply with the

requirements of ANSI 77 Tier 15 loading. Provide pulling irons, 22 mm (0.875 inch) diameter galvanized steel bar with exposed triangular-shaped opening.

- B. Polymer Concrete Pullboxes: Shall be molded of sand, aggregate, and polymer resin, and reinforced with steel, fiberglass, or both. Pullbox shall have open bottom.

2.3 DUCTS

- A. Number and sizes shall be as shown on the drawings.
- B. Ducts (concrete-encased):
 - 1. Plastic Duct:
 - a. NEMA TC6 & 8 and TC9 plastic utilities duct.
 - b. Duct shall be suitable for use with 90° C (194° F) rated conductors.
 - 2. Conduit Spacers: Prefabricated plastic.
- C. Ducts (direct-burial):
 - 1. Plastic duct:
 - a. NEMA TC2 and TC3 Schedule 80 PVC or HDPE conduit.
 - b. Duct shall be suitable for use with 75° C (167° F) rated conductors.
 - 2. Rigid metal conduit: UL6 and NEMA RN1 galvanized rigid metal, half-lap wrapped with 10 mil PVC tape.

2.4 GROUNDING

- A. Ground Rods and Ground Wire: Per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

2.5 WARNING TAPE

- A. 4-mil polyethylene 75 mm (3 inches) wide detectable tape, red with black letters, imprinted with "CAUTION - BURIED ELECTRIC CABLE BELOW" or similar.

2.6 PULL ROPE FOR SPARE DUCTS

- A. Plastic with 890 N (200 lb) minimum tensile strength.

PART 3 - EXECUTION

3.1 MANHOLE AND PULLBOX INSTALLATION

- A. Assembly and installation shall be per the requirements of the manufacturer.
 - 1. Install manholes and pullboxes level and plumb.
 - 2. Units shall be installed on a 300 mm (12 inches) thick level bed of 90% compacted granular fill, well-graded from the 25 mm (1 inches) sieve to the No. 4 sieve. Granular fill shall be compacted with a minimum of four passes with a plate compactor.
- B. Access: Ensure the top of frames and covers are flush with finished grade.

C. Grounding in Manholes:

1. Ground Rods in Manholes: Drive a ground rod into the earth, through the floor sleeve, after the manhole is set in place. Fill the sleeve with sealant to make a watertight seal. Rods shall protrude approximately 100 mm (4 inches) above the manhole floor.
2. Install a No. 3/0 AWG bare copper ring grounding conductor around the inside perimeter of the manhole and anchor to the walls with metallic cable clips.
3. Connect the ring grounding conductor to the ground rod by an exothermic welding process.
4. Bond the ring grounding conductor to the duct bank equipment grounding conductors, the exposed non-current carrying metal parts of racks, sump covers, and like items in the manholes with a minimum No. 6 AWG bare copper jumper using an exothermic welding process.

3.2 TRENCHING

- A. Refer to Section 31 20 00, EARTH MOVING for trenching, backfilling, and compaction.
- B. Before performing trenching work at existing facilities, a Ground Penetrating Radar Survey shall be carefully performed by a certified technician to reveal all existing underground ducts, conduits, cables, and other utility systems.
- C. Work with extreme care near existing ducts, conduits, and other utilities to avoid damaging them.
- D. Cut the trenches neatly and uniformly.
- E. For Concrete-Encased Ducts:
 1. After excavation of the trench, stakes shall be driven in the bottom of the trench at 1.2 M (4 foot) intervals to establish the grade and route of the duct bank.
 2. Pitch the trenches uniformly toward manholes or both ways from high points between manholes for the required duct line drainage. Avoid pitching the ducts toward buildings wherever possible.
 3. 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 the concrete envelope can be poured without soil inclusions. Forms are required where the soil is not self-supporting.
 4. After the concrete-encased duct has sufficiently cured, the trench shall be backfilled to grade with earth, and appropriate warning tape installed.

- F. Individual conduits to be installed under existing paved areas and roads that cannot be disturbed shall be jacked into place using rigid metal conduit, or bored using plastic utilities duct or PVC conduit, as approved by the COTR.

3.3 DUCT INSTALLATION

A. General Requirements:

1. Ducts shall be in accordance with the NEC, as shown on the drawings, and as specified.
2. Join and terminate ducts with fittings recommended by the manufacturer.
3. Slope ducts to drain towards manholes and pullboxes, and away from building and equipment entrances. Pitch not less than 100 mm (4 inch) in 30 M (100 feet).
4. Underground conduit stub-ups and sweeps to equipment inside of buildings shall be galvanized rigid metal conduit half-lap wrapped with PVC tape, and shall extend a minimum of 1.5 M (5 feet) outside the building foundation. Tops of conduits below building slab shall be minimum 610 mm (24 inches) below bottom of slab.
5. Stub-ups and sweeps to equipment mounted on outdoor concrete slabs shall be galvanized rigid metal conduit half-lap wrapped with PVC tape, and shall extend a minimum of 1.5 M (5 feet) away from the edge of slab.
6. Install insulated grounding bushings on the conduit terminations.
7. Radius for sweeps shall be sufficient to accomplish pulls without damage. Minimum radius shall be six times conduit diameter.
8. All multiple conduit runs shall have conduit spacers. Spacers shall securely support and maintain uniform spacing of the duct assembly a minimum of 75 mm (3 inches) above the bottom of the trench during the concrete pour. Spacer spacing shall not exceed 1.5 M (5 feet). Secure spacers to ducts and earth to prevent floating during concrete pour. Provide nonferrous tie wires to prevent displacement of the ducts during concrete pour. Tie wires shall not act as substitute for spacers.
9. Duct lines shall be installed no less than 300 mm (12 inches) from other utility systems, such as water, sewer, chilled water.
10. Clearances between individual ducts:
 - a. For similar services, not less than 75 mm (3 inches).
 - b. For power and signal services, not less than 150 mm (6 inches).
11. Duct lines shall terminate at window openings in manhole walls as shown on the drawings. All ducts shall be fitted with end bells.

12. Couple the ducts with proper couplings. Stagger couplings in rows and layers to ensure maximum strength and rigidity of the duct bank.
 13. Keep ducts clean of earth, sand, or gravel, and seal with tapered plugs upon completion of each portion of the work.
 14. Spare Ducts: Where spare ducts are shown, they shall have a nylon pull rope installed. They shall be capped at each end and labeled as to location of the other end.
 15. Duct Identification: Place continuous strip of warning tape approximately 300 mm (12 inches) above ducts before backfilling trenches. Warning tape shall be preprinted with proper identification.
 16. Duct Sealing: Seal ducts, including spare ducts, at building entrances and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of foreign objects and material, moisture, and gases.
 17. Use plastic ties to secure cables to insulators on cable arms. Use minimum two ties per cable per insulator.
- B. Concrete-Encased Ducts:
1. Install concrete-encased ducts for medium-voltage systems, low-voltage systems, and signal systems, unless otherwise shown on the drawings.
 2. Duct banks shall be single or multiple duct assemblies encased in concrete. Ducts shall be uniform in size and material throughout the installation.
 3. Tops of concrete-encased ducts shall be:
 - a. Not less than 600 mm (24 inches) and not less than shown on the drawings, below finished grade.
 - b. Not less than 750 mm (30 inches) and not less than shown on the drawings, below roads and other paved surfaces.
 - c. Additional burial depth shall be required in order to accomplish NEC-required minimum bend radius of ducts.
 - d. Conduits crossing under grade slab construction joints shall be installed a minimum of 1.2 M (4 feet) below slab.
 4. Extend the concrete envelope encasing the ducts not less than 75 mm (3 inches) beyond the outside walls of the outer ducts.
 5. Within 3 M (10 feet) of building and manhole wall penetrations, install reinforcing steel bars at the top and bottom of each concrete envelope to provide protection against vertical shearing.

6. Install reinforcing steel bars at the top and bottom of each concrete envelope of all ducts underneath roadways and parking areas.
7. Where new ducts and concrete envelopes are to be joined to existing manholes, pullboxes, ducts, and concrete envelopes, make the joints with the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions.
8. Duct joints in concrete may be placed side by side horizontally, but shall be staggered at least 150 mm (6 inches) vertically.
9. Pour each run of concrete envelope between manholes or other terminations in one continuous pour. If more than one pour is necessary, terminate each pour in a vertical plane and install 19 mm (0.75 inch) reinforcing rod dowels extending 450 mm (18 inches) into concrete on both sides of joint near corners of envelope.
10. Pour concrete so that open spaces are uniformly filled. Do not agitate with power equipment unless approved by COTR.

C. Direct-Burial Ducts:

1. Install direct-burial ducts only where shown on the drawings. Provide direct-burial ducts only for low-voltage power and lighting branch circuits.
2. Tops of ducts shall be:
 - a. Not less than 600 mm (24 inches) and not less than shown on the drawings, below finished grade.
 - b. Not less than 750 mm (30 inches) and not less than shown on the drawings, below roads and other paved surfaces.
 - c. Additional burial depth shall be required in order to accomplish NEC-required minimum bend radius of ducts.
3. Do not kink the ducts. Compaction shall not deform the ducts.

D. Connections to Manholes: Ducts connecting to manholes shall be flared to have an enlarged cross-section to provide additional shear strength. Dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 300 mm (12 inches) in each direction. Perimeter of the duct bank opening in the manhole shall be flared toward the inside or keyed to provide a positive interlock between the duct and the wall of the manhole. Use vibrators when this portion of the encasement is poured to ensure a seal between the envelope and the wall of the structure.

E. Connections to Existing Manholes: For duct connections to existing manholes, break the structure wall out to the dimensions required and preserve the steel in the structure wall.

Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

- F. Connections to Existing Ducts: Where connections to existing ducts are indicated, excavate around the ducts as necessary. Cut off the ducts and remove loose concrete from inside before installing new ducts. Provide a reinforced-concrete collar, poured monolithically with the new ducts, to take the shear at the joint of the duct banks.
- G. Partially-Completed Ducts: During construction, wherever a construction joint is necessary in a duct bank, prevent debris such as mud and dirt from entering ducts by providing suitable plugs. Fit concrete envelope of a partially completed ducts with reinforcing steel extending a minimum of 600 mm (2 feet) back into the envelope and a minimum of 600 mm (2 feet) beyond the end of the envelope. Provide one No. 4 bar in each corner, 75 mm (3 inches) from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 300 mm (12 inches) apart. Restrain reinforcing assembly from moving during pouring of concrete.

3.4 ACCEPTANCE CHECKS AND TESTS

- A. Duct Testing and Cleaning:
 - 1. Upon completion of the duct installation, a standard flexible mandrel shall be pulled through each duct to loosen particles of earth, sand, or foreign material left in the duct, and to test for out-of-round conditions.
 - 2. The mandrel shall be not less than 300 mm (12 inches) long, and shall have a diameter not less than 13 mm (0.5 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.
 - 3. If testing reveals obstructions or out-of-round conditions, the Contractor shall replace affected section(s) of duct and retest to the satisfaction of the COTR at no cost to the Government.
 - 4. Mandrel pulls shall be witnessed by the COTR.

---END---

SECTION 26 05 73 OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the overcurrent protective device coordination study, indicated as the study in this section.
- B. A short-circuit and selective coordination study shall be prepared for the electrical overcurrent devices to be installed under this project.
- C. The study shall present a well-coordinated time-current analysis of each overcurrent protective device from the individual device up to the utility source.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.
- B. Section 26 13 16, MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES: Medium-voltage fusible interrupter switches.
- C. Section 26 24 16, PANELBOARDS: Low-voltage panelboards.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. The study shall be prepared by the equipment manufacturer.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Product data on the software program to be used for the study. Software shall be in mainstream use in the industry, shall provide device settings and ratings, and shall show selective coordination by time-current drawings.
 - 2. Complete study as described in paragraph 1.6. Submittal of the study shall be well-coordinated with submittals of the shop drawings for equipment in related specification sections.
 - 3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the Contractor that the overcurrent protective devices have been set in accordance with the approved study.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 242-01 Protection and Coordination of Industrial and Commercial Power Systems
 - 399-97 Industrial and Commercial Power Systems Analysis
 - 1584a-04 Guide for Performing Arc-Flash Hazard Calculations

1.6 STUDY REQUIREMENTS

- A. The study shall include one line diagram, short-circuit and ground fault analysis, and protective coordination plots for all overcurrent protective devices.
- B. One Line Diagram:
 - 1. Show all electrical equipment and wiring to be protected by the overcurrent devices.
 - 2. Show the following specific information:
 - a. Calculated fault impedance, X/R ratios, and short-circuit values at each feeder and branch circuit bus.
 - b. Relay, circuit breaker, and fuse ratings.
 - c. Generator kW/kVA and transformer kVA and voltage ratings, percent impedance, X/R ratios, and wiring connections.
 - d. Voltage at each bus.
 - e. Identification of each bus, matching the identification on the drawings.
 - f. Conduit, conductor, and busway material, size, length, and X/R ratios.
- C. Short-Circuit Study:
 - 1. The study shall be performed using computer software designed for this purpose. Pertinent data and the rationale employed in developing the calculations shall be described in the introductory remarks of the study.
 - 2. Calculate the fault impedance to determine the available short-circuit and ground fault currents at each bus. Incorporate applicable motor and/or generator contribution in determining the momentary and interrupting ratings of the overcurrent protective devices.
 - 3. Present the results of the short-circuit study in a table. Include the following:
 - a. Device identification.
 - b. Operating voltage.

- c. Overcurrent protective device type and rating.
 - d. Calculated short-circuit current.
- D. Coordination Curves:
- 1. Prepare the coordination curves to determine the required settings of overcurrent protective devices to demonstrate selective coordination. Graphically illustrate on log-log paper that adequate time separation exists between devices, including the utility company upstream device if applicable. Plot the specific time-current characteristics of each overcurrent protective device in such a manner that all devices are clearly depicted.
 - 2. The following specific information shall also be shown on the coordination curves:
 - a. Device identification.
 - b. Potential transformer and current transformer ratios.
 - c. Three-phase and single-phase ANSI damage points or curves for each cable, transformer, or generator.
 - d. Applicable circuit breaker or protective relay characteristic curves.
 - e. No-damage, melting, and clearing curves for fuses.
 - f. Transformer in-rush points.
 - 3. Develop a table to summarize the settings selected for the overcurrent protective devices. Include the following in the table:
 - a. Device identification.
 - b. Protective relay or circuit breaker potential and current transformer ratios, sensor rating, and available and suggested pickup and delay settings for each available trip characteristic.
 - c. Fuse rating and type.

1.7 ANALYSIS

- A. Analyze the short-circuit calculations, and highlight any equipment determined to be underrated as specified. Propose solutions to effectively protect the underrated equipment.

1.8 ADJUSTMENTS, SETTINGS, AND MODIFICATIONS

- A. Final field settings and minor modifications of the overcurrent protective devices shall be made to conform with the study, without additional cost to the Government.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

---END---

SECTION 26 09 23 LIGHTING CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation and connection of the lighting controls.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General requirements that are common to more than one section of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- D. Section 26 24 16, PANELBOARDS: Panelboard enclosure and interior bussing used for lighting control panels.
- E. Section 26 27 26, WIRING DEVICES: Wiring devices used for control of the lighting systems.
- F. Section 26 51 00, INTERIOR LIGHTING: Luminaire ballast and drivers used in control of lighting systems.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit the following information for each type of lighting controls.
 - b. Material and construction details.
 - c. Physical dimensions and description.
 - d. Wiring schematic and connection diagram.
 - e. Installation details.
 - 2. Manuals:

- a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
- a. Certification by the Contractor that the lighting control systems have been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. Green Seal (GS):
GC-12-03 Occupancy Sensors
- C. National Electrical Manufacturer's Association (NEMA):
C136.10-10 American National Standard for Roadway and Area Lighting Equipment—Locking-Type Photocontrol Devices and Mating Receptacles—Physical and Electrical Interchangeability and Testing
- D. National Fire Protection Association (NFPA):
70-14 National Electrical Code (NEC)
- E. Underwriters Laboratories, Inc. (UL):
20 Standard for General-Use Snap Switches
773-95 Standard for Plug-In Locking Type Photocontrols for Use with Area Lighting
773A-06 Nonindustrial Photoelectric Switches for Lighting Control
98-04 Enclosed and Dead-Front Switches
916-07 Standard for Energy Management Equipment Systems
917-06 Clock Operated Switches
924-06 Emergency Lighting and Power Equipment (for use when controlling emergency circuits).

PART 2 - PRODUCTS

2.1 ELECTRONIC TIME SWITCHES

- A. Electronic, solid-state programmable units with alphanumeric display; complying with UL 916 and or 917.
 - 1. Contact Configuration: DPST.
 - 2. Contact Rating: 30-A inductive or resistive 120-277 volt 20-A ballast load, 120-277 volt.
 - 3. Astronomical Clock: Capable of switching a load on at sunset and off at sunrise, and automatically changing the settings each day in accordance with seasonal changes of sunset and sunrise. Additionally, it shall be programmable to a fixed on/off weekly schedule.
 - 4. Power Backup: Battery or capacitor for schedules and time clock.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Solid state, with SPST dry contacts rated for 1800 VA tungsten or 1000 VA inductive, complying with UL 773A.
 - 1. Light-Level Monitoring Range: 16.14 to 108 lx (1.5 to 10 fc), with adjustable turn-on and turn-off levels.
 - 2. Time Delay: 15-second minimum.
 - 3. Surge Protection: Metal-oxide varistor.
 - 4. Mounting: Twist lock, with base-and-stem mounting or stem-and-swivel mounting accessories as required.

2.3 INDOOR OCCUPANCY SENSORS

- A. Wall- or ceiling-mounting, solid-state units with a power supply and relay unit, suitable for the environmental conditions in which installed.
 - 1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a 1 to 15 minute adjustable time delay for turning lights off.
 - 2. Sensor Output: Contacts rated to operate the connected relay. Sensor shall be powered from the relay unit.
 - 3. Relay Unit: Dry contacts rated for 20A ballast load at 120 volt and 277 volt, for 13A tungsten at 120 volt, and for 1 hp at 120 volt.
 - 4. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.

- b. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 6. Bypass Switch: Override the on function in case of sensor failure.
 7. Manual/automatic selector switch.
 8. Automatic Light-Level Sensor: Adjustable from 21.5 to 2152 lx (2 to 200 fc); keep lighting off when selected lighting level is present.
 9. Faceplate for Wall-Switch Replacement Type: Refer to wall plate material and color requirements for toggle switches, as specified in Section 26 27 26, WIRING DEVICES.
- B. Dual-technology Type: Ceiling mounting; combination PIR and ultrasonic detection methods, field-selectable.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of 150 mm (6-inch) minimum movement of any portion of a human body that presents a target of not less than 232 sq. cm (36 sq. in), and detect a person of average size and weight moving not less than 305 mm (12 inches) in either a horizontal or a vertical manner at an approximate speed of 305 mm/s (12 inches/s).
- C. Detection Coverage: Shall be sufficient to provide coverage as required by sensor locations shown on drawing.

2.4 LIGHTING CONTROL SYSTEM – RELAY PANEL TYPE (STAND ALONE)

- A. System Description:
1. The lighting control system shall be with lighting relay panels. Lighting control devices connect to the relay panels and communicate via the panel controller. System includes all interfaces and wiring, relay panels, control modules, input modules, panel processors, relays, photocells, switches, dimmers, time clock, and occupancy sensors.
 2. System shall include the capability of BACnet IP communication with other systems as described.
 3. Panel Controller shall provide programmable operation of lights connected via system relays and controlled with system devices. System software shall provide control of relays and control devices, time and sequence scheduling, timed out and

blink light operation and monitoring and reporting of system events and components.

Initial programming shall be as shown on plans and schedules.

- B. Panel Controller: Comply with UL 508; programmable, solid-state, astronomic 365-day control unit with non-volatile memory, mounted in preassembled relay panel with low-voltage-controlled, latching-type, single-pole lighting circuit relays. Controller shall be capable of receiving inputs from control devices and other sources. Where indicated, a limited number of digital or analog, low-voltage control-circuit outputs shall be supported by control unit and circuit boards associated with relays.
- C. Cabinet: Steel with hinged, locking door. Barriers separate low-voltage and line-voltage components.
- D. Directory: Identifies each relay as to load controlled.
- E. System Power Supply: Transformer and full-wave rectifier with filtered dc output for panel, controllers and control devices. Feed from an equipment emergency circuit at a minimum.
- F. Single-Pole Relays: Mechanically held unless otherwise indicated; split-coil, momentary-pulsed type, rated 20 A, 125 volt AC for tungsten filaments and 20 A, 277 volt AC for electronic ballasts, 50,000 cycles at rated capacity.
- G. Control Devices: All occupancy sensors (Ultrasonic, IR and Dual Technology type), photocells, switches and timers shall be provided with system and designed to operate on system network. Supplemental power packs shall be provided as required for multiple control devices. This equipment shall be identified in shop drawing submission.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC, manufacturer's instructions and as shown on the drawings or specified.
- B. Aim outdoor photoelectric sensor according to manufacturer's recommendations. Set adjustable window slide for 1 footcandle turn-on.
- C. Aiming for wall-mounted and ceiling-mounted motion sensor switches shall be per manufacturer's recommendations.
- D. Set occupancy sensor "on" duration to 15 minutes.
- E. Locate photoelectric sensors as indicated and in accordance with the manufacturer's recommendations. Adjust sensor for the available light level at the typical work plane for that area.
- F. Label time switches and contactors with a unique designation.

G. Program lighting control panels per schedule on drawings.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations.
- B. Upon completion of installation, conduct an operating test to show that equipment operates in accordance with requirements of this section.
- C. Test for full range of dimming ballast and dimming controls capability. Observe for visually detectable flicker over full dimming range.
- D. Test occupancy sensors for proper operation. Observe for light control over entire area being covered.

3.3 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the lighting control devices are in good operating condition and properly performing the intended function in the presence of COTR.

3.4 INSTRUCTION

- A. Furnish the services of a factory-trained technician for one 8-hour training period for instructing personnel in the maintenance and operation of the lighting control system on the dates requested by the COTR.
- B. Contractor shall submit written instructions on training and maintenance as reviewed in training session.

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SECTION 26 12 19
PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of the pad-mounted, liquid-filled, medium-voltage transformers, indicated as transformers in this section.

1.2 RELATED WORK

- A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.
- B. Section 09 06 00, SCHEDULE FOR FINISHES: Finishes for electrical equipment.
- C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- D. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Medium-voltage cables.
- E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground currents.
- F. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Manholes, pull-boxes, and ducts for underground raceway systems.
- G. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Transformers shall be thoroughly tested at the factory to ensure that there are no electrical or mechanical defects. Tests shall be conducted as per IEEE Standards. Factory tests shall be certified. The following tests shall be performed:
 - 1. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground.
 - 2. Perform turns-ratio tests at all tap positions.
- B. Furnish four (4) copies of certified manufacturer's factory test reports to the COTR prior to shipment of the transformers to ensure that the transformers have been successfully tested as specified.

1.5 SUBMITTALS

A. Submit six copies of the following in accordance with Section 26 05 11,
REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1. Shop Drawings:

- a. Submit sufficient information to demonstrate compliance with drawings and specifications.
- b. Include electrical ratings, nameplate data, impedance, outline drawing with dimensions and front, top, and side views, weight, mounting details, decibel rating, termination information, temperature rise, no-load and full-load losses, regulation, overcurrent protection, connection diagrams, and accessories.
- c. Complete nameplate data, including manufacturer's name and catalog number.

2. Manuals:

- a. When submitting the shop drawings, submit companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - 1) Identify terminals on wiring diagrams to facilitate installation, maintenance, and operation.
 - 2) Indicate on wiring diagrams the internal wiring for each piece of equipment and interconnections between the pieces of equipment.
 - 3) Approvals will be based on complete submissions of manuals, together with shop drawings.
- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
 - 1) Update the manual to include any information necessitated by shop drawing approval.
 - 2) Show all terminal identification.
 - 3) Include information for testing, repair, troubleshooting, assembly, disassembly, and recommended maintenance intervals.
 - 4) Provide a replacement parts list with current prices. Include a list of recommended spare parts, tools, and instruments for testing and maintenance purposes.

B. Certifications:

1. Two weeks prior to the final inspection, submit the following certifications.

- a. Certification by the manufacturer that the transformers conform to the requirements of the drawings and specifications.
- b. Certification by the Contractor that the transformers have been properly installed, connected, and tested.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American National Standards Institute (ANSI):

C37.47-00 High Voltage Current-Limiting Type Distribution Class
Fuses and Fuse Disconnecting Switches

C57.12.00-00..... Liquid-Immersed Distribution, Power and Regulating
Transformers

C57.12.26-92..... Pad-Mounted, Compartmental-Type, Self-Cooled,
Three-Phase Distribution Transformers for Use with
Separable Insulated High-Voltage Connectors (34500 Grd
Y/19920 V and Below, 2500 kVA and Smaller)

C57.12.28-05..... Pad-Mounted Equipment - Enclosure Integrity

C57.12.34-10..... Pad-Mounted, Compartmental-Type, Self-Cooled, Three-
Phase Distribution Transformers, 5 MVA and Smaller; High
Voltage, 34.5 kV Nominal System Voltage and Below; Low
Voltage, 15kV Nominal System Voltage and Below

C. American Society for Testing and Materials (ASTM):

D3487-08 Standard Specification for Mineral Insulating Oil Used in
Electrical Apparatus

D. Institute of Electrical and Electronic Engineers (IEEE):

C2-07 National Electrical Safety Code

C57.12.10-11..... Liquid-Immersed Power Transformers

C57.12.90-10..... Test Code for Liquid-Immersed Distribution, Power, and
Regulating Transformers

C62.11-06 Metal-Oxide Surge Arresters for AC Power Circuits

48-09..... Test Procedures and Requirements for Alternating-Current
Cable Terminations Used on Shielded Cables Having

- Laminated Insulation Rated 2.5kV Through 765kV or
Extruded Insulation Rated 2.5kV Through 500kV
- 386-06 Separable Insulated Connector Systems for Power
Distribution Systems Above 600 V
- 592-07 Exposed Semiconducting Shields on High-Voltage Cable
Joints and Separable Connectors
- E. International Code Council (ICC):
IBC-12 International Building Code
- F. National Electrical Manufacturers Association (NEMA):
LA 1-09 Surge Arresters
TP 1-02 Guide for Determining Energy Efficiency for Distribution
Transformers
TR 1-00 Transformers, Regulators, and Reactors
- G. National Fire Protection Association (NFPA):
70-11 National Electrical Code (NEC)
- H. Underwriters Laboratories Inc. (UL):
467-07 Grounding and Bonding Equipment

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Transformers shall be in accordance with ANSI, ASTM, IEEE, NEMA, NFPA, UL as shown on the drawings, and as specified herein. Each transformer shall be assembled as an integral unit by a single manufacturer.
- B. Transformers shall be complete, outdoor type, continuous duty, integral assembly, grounded, tamper-resistant, and with liquid-immersed windings.
- C. Ratings shall not be less than shown on the drawings.
- D. Completely fabricate transformers at the factory so that only the external cable connections are required at the project site.
- E. Thoroughly clean, phosphatize, and finish all the metal surfaces at the factory with a rust-resistant primer and dark green enamel finish coat, except where a different color is specified in Section 09 06 00, SCHEDULE FOR FINISHES. All surfaces of the transformer that will be in contact with the concrete pad shall be treated with corrosion-resistant compounds and epoxy resin or a rubberized sealing compound.

2.2 COMPARTMENTS

- A. Construction:

1. Enclosures shall be weatherproof and in accordance with ANSI C57.12.28.
2. The medium- and low-voltage compartments shall be separated with a steel barrier that extends the full height and depth of the compartments.
3. The compartments shall be constructed of sheet steel (gauge to meet ANSI requirements) with bracing and with reinforcing gussets using jig welds to assure rectangular rigidity.
4. All bolts, nuts, and washers shall be zinc-plated steel.
5. Sufficient space shall be provided for equipment, cabling, and terminations within the compartments.
6. Affix transformer nameplate permanently within the low-voltage compartment. Voltage and kVA rating, connection configuration, impedance, date of manufacture, and serial number shall be shown on the nameplate.

B. Doors:

1. Provide a separate door for each compartment with provisions for a single padlock to secure all doors. Provide each compartment door with open-position doorstops and corrosion-resistant tamperproof hinges welded in place. The medium-voltage compartment door shall be mechanically prevented from opening unless the low-voltage compartment door is open.
2. The secondary compartment door shall have a one-piece steel handle and incorporate three-point locking mechanisms.
3. Provide a 50 mm (2 inches) size padlock for each assembly, as approved by the COTR. Padlocks shall be keyed to the COTR's established key set. Firmly attach the padlock to the door assembly by a chain.

2.3 BIL RATING

- A. 15 kV class equipment shall have a minimum 95 kV BIL rating.

2.4 TRANSFORMER FUSE ASSEMBLY

- A. The primary fuse assembly shall be load-break combination fuse and dry-well fuse holder rated for system voltage, rated for 10 load makes and 10 load breaks, with rated 200 amp load current at 75% power factor, 10,000 symmetrical A close-in on fault duty, and 95 kV BIL. The entire fuse assembly shall be removable through the use of hot stick.
1. The fuses shall be concealed, hot stick removable, 50,000 A symmetrical interrupting, non-expulsion, current-limiting primary distribution type, of the size and voltage class as shown on the drawings. The fuses shall operate within the fuse

holder as a unit disconnecting means. Fuses shall be in accordance with ANSI C37.47.

2. Transformers shall not have internal "weak link" fuses that require transformer tank cover removal for replacement.
3. For units above 500 kVA using fusing above the 50 A 15 kV and 100 A 5 kV application, a clip-mounted arrangement of the current limiting fuses (i.e., live-front configuration) is required.

2.5 PRIMARY CONNECTIONS

- A. Primary connections shall be 200 A dead-front loadbreak wells and inserts for cable sizes shown on the drawings.
- B. Surge Arresters: Distribution class, one for each primary phase, complying with IEEE C62.11 and NEMA LA 1, supported from tank wall.

2.6 MEDIUM-VOLTAGE SWITCH

- A. The transformer primary disconnect switch shall be an oil-immersed, internal, gang-operated, load-interrupter type, rated at ampacity and system voltage as shown on the drawings, with a minimum momentary withstand rating of not less than the calculated available fault current shown on the drawings.
- B. For radial feeds, switch shall be a two-position, on-off, manual switch located in the medium-voltage compartment and hot-stick-operated.

2.7 MEDIUM-VOLTAGE TERMINATIONS

- A. Terminate the medium-voltage cables in the primary compartment with 200 A loadbreak premolded rubber elbow connectors, suitable for submersible applications. Elbow connectors shall have a semi-conductive shield material covering the housing. The separable connector system shall include the loadbreak elbow, the bushing insert, and the bushing well. Separable connectors shall comply with the requirements of IEEE 386, and shall be interchangeable between suppliers. Allow sufficient slack in medium-voltage cable, ground, and drain wires to permit elbow connectors to be moved to their respective parking stands.
- B. Ground metallic cable shield with a cable shield grounding adapter, consisting of a solderless connector enclosed in watertight rubber housing covering the entire assembly, bleeder wire, and ground braid.

2.8 LOW-VOLTAGE EQUIPMENT

- A. Mount the low-voltage bushings, and hot stick in the low-voltage compartment.

- B. The low-voltage leads shall be brought out of the tank by epoxy pressure tight bushings, and shall be standard arrangement.
- C. Tin-plate the low-voltage neutral terminal and isolate from the transformer tank. Provide a removable ground strap sized in accordance with the NEC and connect between the secondary neutral and ground pad.

2.9 TRANSFORMERS

- A. Transformer ratings shall be as shown on drawings. kVA ratings shown on the drawings are for continuous duty without the use of cooling fans.
- B. Temperature rises shall not exceed the NEMA TR 1 standards of 65° C (149° F) by resistance.
- C. Transformer insulating material shall be mineral oil in accordance with ASTM D 3487.
- D. Transformer impedance shall be not less than 4-1/2% for sizes 150 kVA and larger. Impedance shall be as shown on the drawings.
- E. Sound levels shall conform to NEMA TR 1 standards.
- F. Primary and Secondary Windings for Three-Phase Transformers:
 - 1. Primary windings shall be delta-connected.
 - 2. Secondary windings shall be wye-connected, except where otherwise indicated on the drawings. Provide isolated neutral bushings for secondary wye-connected transformers.
 - 3. Secondary leads shall be brought out through pressure-tight epoxy bushings.
- G. Primary windings shall have four 2-1/2% full-capacity voltage taps; two taps above and two taps below rated voltage.
- H. Core and Coil Assemblies:
 - 1. Cores shall be grain-oriented, non-aging, silicon steel to minimize losses.
 - 2. Core and coil assemblies shall be rigidly braced to withstand the stresses caused by rough handling during shipment, and stresses caused by any possible short-circuit currents.
 - 3. Coils shall be continuous-winding type without splices except for taps. Material shall be copper.
 - 4. Coil and core losses shall be optimum for efficient operation.
 - 5. Primary, secondary, and tap connections shall be brazed or pressure type.
 - 6. Provide end fillers or tiedowns for coil windings.
- I. The transformer tank, cover, and radiator gauge thickness shall not be less than that required by ANSI.

J. Accessories:

1. Provide standard NEMA features, accessories, and the following:
 - a. No-load tap changer. Provide warning sign.
 - b. Lifting, pulling, and jacking facilities.
 - c. Globe-type valve for oil filtering and draining, including sampling device.
 - d. Pressure relief valve.
 - e. Liquid level gauge and filling plug.
 - f. A grounding pad in the medium- and low-voltage compartments.
 - g. A diagrammatic nameplate.
 - h. Dial-type liquid thermometer with a maximum reading pointer and an external reset.
 - i. Hot stick. Securely fasten hot stick within low-voltage compartment.
2. The accessories shall be made accessible within the compartments without disassembling trims and covers.

K. Transformers shall meet the minimum energy efficiency values per NEMA TP 1:

KVA	(%)
75	98.7
112.5	98.8
150	98.9
225	99.0
300	99.0
500	99.1
750	99.2
1000	99.2
1500	99.3
2000	99.4
2500	99.4

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install transformers outdoors, as shown on the drawings, in accordance with the NEC, and as recommended by the manufacturer.

- B. Anchor transformers with rustproof bolts, nuts, and washers not less than 12 mm (1/2 inch) diameter, in accordance with manufacturer's instructions, and as shown on drawings.
- C. Mount transformers on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm (8 inches) thick, reinforced with a 150 by 150 mm (6 by 6 inches) No. 6 mesh placed uniformly 100 mm (4 inches) from the top of the slab. Slab shall be placed on a 150 mm (6 inches) thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm (4 inches) above the finished grade. Edges above grade shall have 12-1/2 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 200 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.
- D. Grounding:
 - 1. Ground each transformer in accordance with the requirements of the NEC. Install ground rods per the requirements of Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS, to maintain a maximum resistance of 5 ohms to ground.
 - 2. Connect the ground rod to the ground pads in the medium- and low-voltage compartments.
 - 3. Install and connect the cable shield grounding adapter per the manufacturer's instructions. Connect the bleeder wire of the cable shield grounding adapter to the loadbreak or deadbreak elbow grounding point with minimum No. 14 AWG wire, and connect the ground braid to the grounding system with minimum No. 6 AWG bare copper wire. Use soldered or mechanical grounding connectors listed for this purpose.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.

- b. Inspect physical and mechanical condition. Check for damaged or cracked bushings and liquid leaks.
- c. Verify that control and alarm settings on temperature indicators are as specified.
- d. Inspect all field-installed bolted electrical connections, using the calibrated torque-wrench method to verify tightness of accessible bolted electrical connections, and perform thermographic survey after energization under load.
- e. Vacuum-clean transformer interior. Clean transformer enclosure exterior.
- f. Verify correct liquid level in transformer tank.
- g. Verify correct equipment grounding per the requirements of Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- h. Verify the presence and connection of transformer surge arresters, if provided.
- i. Verify that the tap-changer is set at rated system voltage.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the transformers are in good operating condition and properly performing the intended function.

3.4 SPARE PARTS

- A. Deliver the following spare parts for the project to the COTR two weeks prior to final inspection:
 - 1. Six insulated protective caps.
 - 2. One spare set of medium-voltage fuses for each size and type of fuse used in the project.

3.5 INSTRUCTION

- A. The Contractor shall instruct maintenance personnel, for not less than one 2-hour period, on the maintenance and operation of the equipment on the date requested by the COTR.

---END---

SECTION 26 13 16 MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of medium-voltage fusible interrupter switches, indicated as switches in this section.

1.2 RELATED WORK

- A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.
- B. Section 09 06 00, SCHEDULE FOR FINISHES: Finishes for outdoor switches.
- C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- D. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Medium-voltage cables and terminations.
- E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- F. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Switches shall be thoroughly tested at the factory to assure that there are no electrical or mechanical defects. Tests shall be conducted as per UL and ANSI Standards. Factory tests shall be certified. The following tests shall be performed:
 - 1. Verify that fuse sizes and types are in accordance with drawings and Overcurrent Protective Device Coordination Study.
 - 2. Verify tightness of bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
 - 3. Verify operation of mechanical interlocks.
 - 4. Confirm correct operation and sequencing of key-type mechanical interlock systems for multiple switches by attempting closure on locked-open devices, and attempting

- to open locked-closed devices, and making key exchange with devices operated in off-normal positions.
5. Verify correct phase barrier installation.
 6. Verify correct operation of all indicating and control devices.
 7. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 8. Exercise all active components.
 9. Perform an insulation-resistance test, phase to ground, on each bus section, with phases not under test grounded, in accordance with manufacturer's published data.
- B. Furnish four (4) copies of certified manufacturer's factory test reports to the COTR prior to shipment of the switches to ensure that the switches have been successfully tested as specified.
- C. The Government shall have an option to witness the factory tests. All expenses of the Government Representative's trips to witness the testing will be paid by the Government. Notify the COTR not less than 30 days prior to making tests at the factory.

1.5 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
1. Shop Drawings:
 - a. Shop drawings shall be submitted simultaneously with or after the Overcurrent Protective Device Coordination Study.
 - b. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - c. Provide information such as complete electrical ratings, dimensions and approximate design weights, enclosure types, mounting details, materials, required clearances, cable terminations, fuse sizes and class, interrupting ratings, wiring diagrams, front, side and rear elevations, sectional views, safety features, accessories, and nameplate data.
 2. Manuals:
 - a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.

- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals to the COTR two weeks prior to the final inspection.
- 3. Certification: Two weeks prior to the final inspection, submit the following.
 - a. Certification by the manufacturer that switches conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that switches have been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American National Standards Institute (ANSI):
 - C37.57-10 Metal-Enclosed Interrupter Switchgear Assemblies -
Conformance Testing
- C. International Code Council (ICC):
 - IBC-12 International Building Code
- D. Institute of Electrical and Electronics Engineers (IEEE):
 - C37.20.3-01 Metal-Enclosed Interrupter Switchgear
 - C37.47-11 High Voltage (>1000V) Current-Limiting Type Distribution
Class Fuses and Fuse Disconnecting Switches
 - C37.48-05 Guide for Application, Operation and Maintenance of High
Voltage Fuses, Distribution Enclosed Single Pole Air
Switches, Fuse Disconnecting Switches, and Accessories
- E. National Electrical Manufacturers Association (NEMA):
 - C37.22-97 Preferred Ratings and Related Required Capabilities for
Indoor AC Medium-Voltage Switches Used in Metal-
Enclosed Switchgear
- F. National Fire Protection Association (NFPA):
 - 70-14 National Electrical Code (NEC)

PART 2 - PRODUCTS

2.1 MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES

- A. Shall be in accordance with ANSI, IEEE, NEMA, NFPA, as shown on the drawings, and have the following features:

1. Deadfront air break, three-pole gang-operated, interrupter type.
 2. Copper blades.
 4. Interphase barriers for the full length of each pole.
 5. Protective shield to cover the cable connections on the line terminals.
 6. Quick-make, quick-break, manual stored-energy type operation mechanism. The mechanism shall enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability.
 7. External manual operating handle with lock-open padlocking provisions.
 8. When the switches are open, the fuses shall be de-energized.
 9. Current limiting fuses.
 10. Expulsion fuses.
 11. Enclosures:
 - a. NEMA type shown on the drawings. Where the types of switch enclosures are not shown, they shall be the NEMA types which are most suitable for the environmental conditions where the switches are being installed.
 - b. Doors:
 - 1) Concealed or semi-concealed hinges shall be used to attach doors. Weld hinges to the enclosure and door.
 - 2) A separate door for the fuse section. A mechanical interlock shall prevent opening the door unless the switch blades are open, and prevent closing the switch if the door is open.
 - 3) Three point door locking mechanism with suitable handles and padlocking provisions.
 - 4) Safety-glass window for viewing the switch blades.
 - 5) Door stops for the open position.
 - c. Finish:
 - 1) All metal surfaces shall be thoroughly cleaned, phosphatized, primed and painted at the factory.
 - 2) Final finish shall be enamel, lacquer or powder coating. Enamel and powder coatings shall be oven baked. Color shall be light gray.
- B. The minimum momentary current rating shall be 80 kA.
- C. The minimum short-time 2-second current rating shall be 38 kA.
- D. Provide full length ground bar.

2.3 NAMEPLATES AND MIMIC BUS

- A. Nameplates: For Normal Power system, provide laminated black phenolic resin with white core with 12 mm (1/2 inch) engraved lettered nameplates next to each switch. For Essential Electrical System, provide laminated red phenolic resin with white core with 12 mm (1/2 inch) engraved lettered nameplates next to each switch. Nameplates shall indicate equipment served, spaces, or spares in accordance with one line diagram shown on drawings. Nameplates shall be mounted with plated screws on front of switches. Mounting nameplates only with adhesive is not acceptable.
- B. Mimic Bus: Provide an approved mimic bus on front of each switch assembly. Color shall be black for the Normal Power system and red for the Essential Electrical System, either factory-painted plastic or metal strips. Plastic tape shall not be used. Use symbols similar to one line diagram shown on drawings. Plastic or metal strips shall be mounted with plated screws.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install switches in accordance with the NEC, manufacturer's instructions and recommendations, and as shown on the drawings.
- B. Anchor switches with rustproof bolts, nuts, and washers not less than 13 mm (1/2 inch) diameter, in accordance with manufacturer's instructions, and as shown on drawings.
- C. Exterior Location: Mount switches on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm (8 inches) thick, reinforced with a 150 by 150 mm (6 by 6 inches) No. 6 mesh placed uniformly 100 mm (4 inches) from the top of the slab. Slab shall be placed on a 150 mm (6 inches) thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm (4 inches) above the finished grade. Edges above grade shall have 15 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 200 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:

- a. Compare switches nameplate data with specifications and approved shop drawings.
- b. Inspect physical and mechanical condition.
- c. Confirm correct application of manufacturer's recommended lubricants.
- d. Vacuum-clean switch enclosure interior. Clean switch enclosure exterior.
- e. Verify appropriate anchorage and required area clearances.
- f. Verify appropriate equipment grounding.
- g. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
- h. Verify that fuse sizes and types correspond to approved shop drawings.
- i. Inspect all field-installed bolted electrical connections, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization under load.
- j. Exercise all active components.
- k. Confirm correct operation of mechanical interlocks.
- m. Inspect all indicating devices for correct operation.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that switches are in good operating condition, and properly performing the intended function.

3.4 WARNING SIGN

- A. Mount on each entrance door of the outdoor switchboard enclosure, approximately 1500 mm (5 feet) above grade or floor, a clearly lettered warning sign for warning personnel. The sign shall be attached with rustproof metal screws.

3.5 SPARE PARTS

- A. Two weeks prior to the final inspection, provide one (1) set of spare fuses for each switch installed on this project.

3.6 ONE LINE DIAGRAM AND SEQUENCE OF OPERATION

- A. At final inspection, an as-built one line diagram shall be laminated or mounted under acrylic glass, and installed in a frame mounted in the switchgear room or in the outdoor switchgear enclosure.
- B. Furnish a written sequence of operation for the switchgear and connected line side/load side electrical distribution equipment. The sequence of operation shall be laminated or

mounted under acrylic glass, and installed in a frame mounted in the switchgear room or in the outdoor switchgear enclosure.

- C. Deliver an additional four copies of the as-built one line diagram and sequence of operation to the COTR.

3.7 INSTRUCTION

- A. Furnish the services of a factory-trained technician for one 4 hour period for instructing personnel in the operation and maintenance of the switches and related equipment on the date requested by the COTR.

---END---

SECTION 26 22 00 LOW-VOLTAGE TRANSFORMERS

PART 1 – GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of low-voltage dry-type general-purpose transformers, indicated as transformers in this section.

1.2 RELATED WORK

- A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- C. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- E. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, temperature rise, wiring and connection diagrams, plan, front, side, and rear elevations, accessories, and device nameplate data.
 - 2. Manuals:
 - a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets and wiring diagrams.

- 1) Schematic signal and control diagrams, with all terminals identified, matching terminal identification in the transformers.
- 2) Include information for testing, repair, troubleshooting, assembly, disassembly, and factory recommended/required periodic maintenance procedures and frequency.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the transformers conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the transformers have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. International Code Council (ICC):
IBC-12 International Building Code
- C. National Fire Protection Association (NFPA):
70-11 National Electrical Code (NEC)
- D. National Electrical Manufacturers Association (NEMA):
TP1-02 Guide for Determining Energy Efficiency for Distribution Transformers
TR1-00 Transformers, Regulators, and Reactors
- E. Underwriters Laboratories, Inc. (UL):
UL 506-08 Standard for Specialty Transformers
UL 1561-11 Dry-Type General Purpose and Power Transformers
- F. United States Department of Energy
10 CFR Part 431 Energy Efficiency Program for Certain Commercial and Industrial Equipment

PART 2 - PRODUCTS

2.1 TRANSFORMERS

- A. Unless otherwise specified, transformers shall be in accordance with NEMA, NEC, UL and as shown on the drawings.
- B. Transformers shall have the following features:
1. Self-cooled by natural convection, isolating windings, indoor dry-type.
Autotransformers will not be accepted, except as specifically allowed for buck-boost applications.
 2. Rating and winding connections shall be as shown on the drawings.
 3. Ratings shown on the drawings are for continuous duty without the use of cooling fans.
 4. Copper windings.
 5. Insulation systems:
 - a. Transformers 30 kVA and larger: UL rated 220 °C (428 °F) system with an average maximum rise by resistance of 150 °C (302 °F) in a maximum ambient of 40 °C (104 °F).
 - b. Transformers below 30 kVA: Same as for 30 kVA and larger or UL rated 185 °C (365 °F) system with an average maximum rise by resistance of 115 °C (239 °F) in a maximum ambient of 40 °C (104 °F).
 6. Core and coil assemblies:
 - a. Rigidly braced to withstand the stresses caused by short-circuit currents and rough handling during shipment.
 - b. Cores shall be grain-oriented, non-aging, and silicon steel.
 - c. Coils shall be continuous windings without splices except for taps.
 - d. Coil loss and core loss shall be minimized for efficient operation.
 - e. Primary and secondary tap connections shall be brazed or pressure type.
 - f. Coil windings shall have end filters or tie-downs for maximum strength.
 7. Certified sound levels, determined in accordance with NEMA, shall not exceed the following:

Transformer Rating	Sound Level Rating
0 - 9 KVA	40 dB
10 - 50 KVA	45 dB
51 - 150 KVA	50 dB
151 - 300 KVA	55 dB

301 - 500 KVA	60 dB
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8. If not shown on drawings, nominal impedance shall be as permitted by NEMA.
9. Single phase transformers rated 15 kVA through 25 kVA shall have two 5% full capacity taps below normal rated primary voltage. All transformers rated 30 kVA and larger shall have two 2.5% full capacity taps above, and four 2.5% full capacity taps below normal rated primary voltage.
10. Core assemblies shall be grounded to their enclosures with adequate flexible ground straps.
11. Enclosures:
 - a. Comprised of not less than code gauge steel.
 - b. Outdoor enclosures shall be NEMA 3R.
 - c. Temperature rise at hottest spot shall conform to NEMA Standards, and shall not bake and peel off the enclosure paint after the transformer has been placed in service.
 - d. Ventilation openings shall prevent accidental access to live components.
 - e. The enclosure at the factory shall be thoroughly cleaned and painted with manufacturer's prime coat and standard finish.
12. Standard NEMA features and accessories, including ground pad, lifting provisions, and nameplate with the wiring diagram and sound level indicated.
13. Dimensions and configurations shall conform to the spaces designated for their installations.
14. Transformers shall meet the minimum energy efficiency values per NEMA TP1 as listed below:

kVA Rating	Output efficiency (%)
15	97
30	97.5
45	97.7
75	98
112.5	98.2

150	98.3
225	98.5
300	98.6
500	98.7
750	98.8

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation of transformers shall be in accordance with the NEC, as recommended by the equipment manufacturer and as shown on the drawings.
- B. Anchor transformers with rustproof bolts, nuts, and washers, in accordance with manufacturer's instructions, and as shown on drawings.
- C. Install transformers with manufacturer's recommended clearance from wall and adjacent equipment for air circulation. Minimum clearance shall be 150 mm (6 inches).
- D. Install transformers on vibration pads designed to suppress transformer noise and vibrations.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform tests in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical and mechanical condition.
 - c. Inspect all field-installed bolted electrical connections, using the calibrated torque-wrench method to verify tightness of accessible bolted electrical connections.
 - d. Perform specific inspections and mechanical tests as recommended by manufacturer.
 - e. Verify correct equipment grounding.
 - f. Verify proper secondary phase-to-phase and phase-to-neutral voltage after energization and prior to connection to loads.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks, settings, and tests, the contractor shall demonstrate that the transformers are in good operating condition, and properly performing the intended function.

---END---

SECTION 26 24 16 PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of panelboards.

1.2 RELATED WORK

- A. Section 09 91 00, PAINTING: Painting of panelboards.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND
CABLES: Low-voltage conductors.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible
ground fault currents.
- E. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.
- F. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY:
Short circuit and coordination study, and requirements for a coordinated electrical
system.
- G. Section 26 09 23, LIGHTING CONTROLS: Lighting controls integral to panelboards.
- H. Section 26 43 13, SURGE PROTECTIVE DEVICES: Surge protective devices integral to
panelboards.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26
05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11,
REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and
specifications.
 - b. Include electrical ratings, dimensions, mounting details, materials, required
clearances, terminations, weight, circuit breakers, wiring and connection
diagrams, accessories, and nameplate data.
 - 2. Manuals:

- a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering circuit breakers and replacement parts.
 - 1) Include schematic diagrams, with all terminals identified, matching terminal identification in the panelboards.
 - 2) Include information for testing, repair, troubleshooting, assembly, and disassembly.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
- a. Certification by the manufacturer that the panelboards conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the panelboards have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. International Code Council (ICC):
 - IBC-12..... International Building Code
- C. National Electrical Manufacturers Association (NEMA):
 - PB 1-11 Panelboards
 - 250-08..... Enclosures for Electrical Equipment (1,000V Maximum)
- D. National Fire Protection Association (NFPA):
 - 70-14..... National Electrical Code (NEC)
 - 70E-12..... Standard for Electrical Safety in the Workplace
- E. Underwriters Laboratories, Inc. (UL):
 - 50-95..... Enclosures for Electrical Equipment
 - 67-09..... Panelboards
 - 489-09..... Molded Case Circuit Breakers and Circuit Breaker Enclosures

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Panelboards shall be in accordance with NEC, NEMA, UL, as specified, and as shown on the drawings.
- B. Panelboards shall have main breaker or main lugs, bus size, voltage, phases, number of circuit breaker mounting spaces, top or bottom feed, flush or surface mounting, branch circuit breakers, and accessories as shown on the drawings.
- C. Panelboards shall be completely factory-assembled with molded case circuit breakers and integral accessories as shown on the drawings or specified herein.
- D. Non-reduced size copper bus bars, rigidly supported on molded insulators, and fabricated for bolt-on type circuit breakers.
- E. Bus bar connections to the branch circuit breakers shall be the “distributed phase” or “phase sequence” type.
- F. Mechanical lugs furnished with panelboards shall be cast, stamped, or machined metal alloys listed for use with the conductors to which they will be connected.
- G. Neutral bus shall be 100% rated, mounted on insulated supports.
- H. Grounding bus bar shall be equipped with screws or lugs for the connection of equipment grounding conductors.
- I. Bus bars shall be braced for the available short-circuit current as shown on the drawings, but not be less than 10,000 A symmetrical for 120/208 V and 120/240 V panelboards, and 14,000 A symmetrical for 277/480 V panelboards.
- J. In two-section panelboards, the main bus in each section shall be full size. The first section shall be furnished with subfeed lugs on the line side of main lugs only, or through-feed lugs for main breaker type panelboards, and have field-installed cable connections to the second section as shown on the drawings. Panelboard sections with tapped bus or crossover bus are not acceptable.
- K. Series-rated panelboards are not permitted.

2.2 ENCLOSURES AND TRIMS

- A. Enclosures:
 - 1. Provide galvanized steel enclosures, with NEMA rating as shown on the drawings or as required for the environmental conditions in which installed.
 - 2. Enclosures shall not have ventilating openings.
 - 3. Enclosures may be of one-piece formed steel or of formed sheet steel with end and side panels welded, riveted, or bolted as required.

4. Provide manufacturer's standard option for prepunched knockouts on top and bottom endwalls.
5. Include removable inner dead front cover, independent of the panelboard cover.

B. Trims:

1. Hinged "door-in-door" type.
2. Interior hinged door with hand-operated latch or latches, as required to provide access only to circuit breaker operating handles, not to energized parts.
3. Outer hinged door shall be securely mounted to the panelboard enclosure with factory bolts, screws, clips, or other fasteners, requiring a key or tool for entry. Hand-operated latches are not acceptable.
4. Inner and outer doors shall open left to right.
5. Trims shall be flush or surface type as shown on the drawings.

2.3 MOLDED CASE CIRCUIT BREAKERS

- A. Circuit breakers shall be per UL, NEC, as shown on the drawings, and as specified.
- B. Circuit breakers shall be bolt-on type.
- C. Circuit breakers shall have minimum interrupting rating as required to withstand the available fault current, but not less than:
 1. 120/208 V Panelboard: 10,000 A symmetrical.
 2. 120/240 V Panelboard: 10,000 A symmetrical.
 3. 277/480 V Panelboard: 14,000 A symmetrical.
- D. Circuit breakers shall have automatic, trip free, non-adjustable, inverse time, and instantaneous magnetic trips for less than 400 A frame. Circuit breakers with 400 A frames and above shall have magnetic trip, adjustable from 5x to 10x. Breaker trip setting shall be set in the field, based on the approved protective device study as specified in Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY
- E. Circuit breaker features shall be as follows:
 1. A rugged, integral housing of molded insulating material.
 2. Silver alloy contacts.
 3. Arc quenchers and phase barriers for each pole.
 4. Quick-make, quick-break, operating mechanisms.
 5. A trip element for each pole, thermal magnetic type with long time delay and instantaneous characteristics, a common trip bar for all poles and a single operator.
 6. Electrically and mechanically trip free.
 7. An operating handle which indicates closed, tripped, and open positions.

8. An overload on one pole of a multi-pole breaker shall automatically cause all the poles of the breaker to open.
9. Ground fault current interrupting breakers, shunt trip breakers, lighting control breakers (including accessories to switch line currents), or other accessory devices or functions shall be provided where shown on the drawings.

2.4 SURGE PROTECTIVE DEVICES

- A. Where shown on the drawings, furnish panelboards with integral surge protective devices. Refer to Section 26 43 13, SURGE PROTECTIVE DEVICES.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the manufacturer's instructions, the NEC, as shown on the drawings, and as specified.
- B. Locate panelboards so that the present and future conduits can be conveniently connected.
- D. Install a printed schedule of circuits in each panelboard after approval by the COTR. Schedules shall reflect final load descriptions, room numbers, and room names connected to each circuit breaker. Schedules shall be printed on the panelboard directory cards and be installed in the appropriate panelboards
- E. Mount panelboards such that the maximum height of the top circuit breaker above the finished floor shall not exceed 1980 mm (78 inches).
- F. Provide blank cover for each unused circuit breaker mounting space.
- G. For panelboards located in areas accessible to the public, paint the exposed surfaces of the trims with finishes to match surrounding surfaces after the panelboards have been installed. Do not paint nameplates.
- H. Panelboard enclosures shall not be used for conductors feeding through, spliced, or tapping off to other enclosures or devices.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify appropriate anchorage and required area clearances.

- d. Verify that circuit breaker sizes and types correspond to approved shop drawings.
- e. To verify tightness of accessible bolted electrical connections, use the calibrated torque-wrench method or perform thermographic survey after energization.
- f. Vacuum-clean enclosure interior. Clean enclosure exterior.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the panelboards are in good operating condition and properly performing the intended function.

---END---

SECTION 26 27 26 WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of wiring devices.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.
- B. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit and boxes.
- C. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Cables and wiring.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- E. Section 26 51 00, INTERIOR LIGHTING: Fluorescent ballasts and LED drivers for use with manual dimming controls.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Include electrical ratings, dimensions, mounting details, construction materials, grade, and termination information.
 - 2. Manuals:
 - a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets and information for ordering replacement parts.

- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
- 3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the wiring devices conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the wiring devices have been properly installed and adjusted.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. National Fire Protection Association (NFPA):
 - 70-14 National Electrical Code (NEC)
- C. National Electrical Manufacturers Association (NEMA):
 - WD 1-10 General Color Requirements for Wiring Devices
 - WD 6-08 Wiring Devices – Dimensional Specifications
- D. Underwriter’s Laboratories, Inc. (UL):
 - 5-11 Surface Metal Raceways and Fittings
 - 20-10 General-Use Snap Switches
 - 231-07 Power Outlets
 - 467-07 Grounding and Bonding Equipment
 - 498-07 Attachment Plugs and Receptacles
 - 943-11 Ground-Fault Circuit-Interrupters
 - 1449-07 Surge Protective Devices
 - 1472-96 Solid State Dimming Controls

PART 2 - PRODUCTS

2.1 RECEPTACLES

- A. General: All receptacles shall comply with NEMA, NFPA, UL, and as shown on the drawings.
 - 1. Mounting straps shall be plated steel, with break-off plaster ears and shall include a self-grounding feature. Terminal screws shall be brass, brass plated or a copper alloy metal.

2. Receptacles shall have provisions for back wiring with separate metal clamp type terminals (four minimum) and side wiring from four captively held binding screws.
- B. Duplex Receptacles: Hospital-grade, single phase, 20 ampere, 120 volts, 2-pole, 3-wire, NEMA 5-20R, with break-off feature for two-circuit operation.
 1. Bodies shall be ivory in color.
 2. Switched duplex receptacles shall be wired so that only the top receptacle is switched. The lower receptacle shall be unswitched.
 3. Duplex Receptacles on Emergency Circuit:
 - a. In rooms without emergency powered general lighting, the emergency receptacles shall be of the self-illuminated type.
 4. Ground Fault Interrupter Duplex Receptacles: Shall be an integral unit, hospital-grade, suitable for mounting in a standard outlet box, with end-of-life indication and provisions to isolate the face due to improper wiring.
 - a. Ground fault interrupter shall be consist of a differential current transformer, solid state sensing circuitry and a circuit interrupter switch. Device shall have nominal sensitivity to ground leakage current of 4-6 milliamperes and shall function to interrupt the current supply for any value of ground leakage current above five milliamperes (+ or – 1 milliampere) on the load side of the device. Device shall have a minimum nominal tripping time of 0.025 second.
 - b. Ground Fault Interrupter Duplex Receptacles (not hospital-grade) shall be the same as ground fault interrupter hospital-grade receptacles except for the hospital-grade listing.
 5. Safety Type Duplex Receptacles:
 - a. Bodies shall be gray in color.
 - 1) Shall permit current to flow only while a standard plug is in the proper position in the receptacle.
 - 2) Screws exposed while the wall plates are in place shall be the tamperproof type.
 6. Duplex Receptacles (not hospital grade): Shall be the same as hospital grade duplex receptacles except for the hospital grade listing and as follows.
 - a. Bodies shall be brown nylon.
- C. Receptacles; 20, 30, and 50 ampere, 250 Volts: Shall be complete with appropriate cord grip plug.

- D. Weatherproof Receptacles: Shall consist of a duplex receptacle, mounted in box with a gasketed, weatherproof, cast metal cover plate and cap over each receptacle opening. The cap shall be permanently attached to the cover plate by a spring-hinged flap. The weatherproof integrity shall not be affected when heavy duty specification or hospital grade attachment plug caps are inserted. Cover plates on outlet boxes mounted flush in the wall shall be gasketed to the wall in a watertight manner.
- E. Surge Protective (TVSS) Receptacles shall have integral surge suppression in line to ground, line to neutral, and neutral to ground modes.
 - 1. TVSS Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 Volts and minimum single transient pulse energy dissipation of 210 Joules.
 - 2. Active TVSS Indication: LED, visible in face of device to indicate device is active or no longer in service.
- F. Cable Reel Receptacles:
 - 1. Reel shall have a heavy-duty spring motor, with self-contained rewind power and non-sparking ratchet assembly, a 4-way roller and adjustable cable stop, and a safety chain. Reel shall lock when desired cable has been payed out, and unlock and retract when cable is pulled to release lock.
 - 2. Reel shall be provided with minimum 40 foot [12m] cable rated for 50 A with required phase conductors, neutral, and equipment grounding conductor. Provide device with NEMA configuration as shown.

2.2 TOGGLE SWITCHES

- A. Toggle switches shall be totally enclosed tumbler type with nylon bodies. Handles shall be ivory in color unless otherwise specified or shown on the drawings.
 - 1. Switches installed in hazardous areas shall be explosion-proof type in accordance with the NEC and as shown on the drawings.
 - 2. Shall be single unit toggle, butt contact, quiet AC type, heavy-duty general-purpose use with an integral self grounding mounting strap with break-off plaster ears and provisions for back wiring with separate metal wiring clamps and side wiring with captively held binding screws.
 - 3. Switches shall be rated 20 amperes at 120-277 Volts AC.

2.3 MANUAL DIMMING CONTROL

- A. Electronic full-wave manual slide dimmer with on/off switch and audible frequency and EMI/RFI suppression filters.

- B. Manual dimming controls shall be fully compatible with fluorescent electronic dimming ballasts and approved by the ballast manufacturer, shall operate over full specified dimming range, and shall not degrade the performance or rated life of the electronic dimming ballast and lamp.
- C. Provide single-pole or three-way, as shown on the drawings.
- D. Manual dimming control and faceplates shall be ivory in color unless otherwise specified.

2.4 WALL PLATES

- A. Wall plates for switches and receptacles shall be type smooth nylon. Oversize plates are not acceptable.
- B. Color shall be ivory unless otherwise specified.
- C. For receptacles or switches mounted adjacent to each other, wall plates shall be common for each group of receptacles or switches.
- D. In areas requiring tamperproof wiring devices, wall plates shall be type 302 stainless steel, and shall have tamperproof screws and beveled edges.

2.5 SURFACE MULTIPLE-OUTLET ASSEMBLIES

- A. Shall have the following features:
 - 1. Enclosures:
 - a. Thickness of steel shall be not less than 1 mm (0.040 inch) for base and cover. Nominal dimensions shall be 40 mm x 70 mm (1-1/2 inches by 2-3/4 inches) with inside cross sectional area not less than 2250 square mm (3-1/2 square inches). The enclosures shall be thoroughly cleaned, phosphatized, and painted at the factory with primer and the manufacturer's standard baked enamel finish.
 - 2. Receptacles shall be duplex, commercial grade. See paragraph 'RECEPTACLES' in this Section. Device cover plates shall be the manufacturer's standard corrosion resistant finish and shall not exceed the dimensions of the enclosure.
 - 3. Unless otherwise shown on drawings, receptacle spacing shall be 600 mm (24 inches) on centers.
 - 4. Conductors shall be as specified in Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE.
 - 5. Installation fittings shall be the manufacturer's standard bends, offsets, device brackets, inside couplings, wire clips, elbows, and other components as required for a complete system.
 - 6. Bond the assemblies to the branch circuit conduit system.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC and as shown as on the drawings.
- B. Install wiring devices after wall construction and painting is complete.
- C. The ground terminal of each wiring device shall be bonded to the outlet box with an approved green bonding jumper, and also connected to the branch circuit equipment grounding conductor.
- D. Outlet boxes for toggle switches and manual dimming controls shall be mounted on the strike side of doors.
- E. Provide barriers in multigang outlet boxes to comply with the NEC.
- F. Coordinate the electrical work with the work of other trades to ensure that wiring device flush outlets are positioned with box openings aligned with the face of the surrounding finish material. Pay special attention to installations in cabinet work, and in connection with laboratory equipment.
- G. Exact field locations of floors, walls, partitions, doors, windows, and equipment may vary from locations shown on the drawings. Prior to locating sleeves, boxes and chases for roughing-in of conduit and equipment, the Contractor shall coordinate exact field location of the above items with other trades.
- H. Install wall switches 1.2 M (48 inches) above floor, with the toggle OFF position down.
- I. Install wall dimmers 1.2 M (48 inches) above floor.
- J. Install receptacles 450 mm (18 inches) above floor, and 152 mm (6 inches) above counter backsplash or workbenches. Install specific-use receptacles at heights shown on the drawings.
- K. Install vertically mounted receptacles with the ground pin up. Install horizontally mounted receptacles with the ground pin to the right.
- L. When required or recommended by the manufacturer, use a torque screwdriver. Tighten unused terminal screws.
- M. Label device plates with a permanent adhesive label listing panel and circuit feeding the wiring device.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform manufacturer's required field checks in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Inspect physical and electrical condition.

- b. Vacuum-clean surface metal raceway interior. Clean metal raceway exterior.
- c. Test wiring devices for damaged conductors, high circuit resistance, poor connections, inadequate fault current path, defective devices, or similar problems using a portable receptacle tester. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.
- d. Test GFCI receptacles.

---END---

SECTION 26 29 21 ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of fused and unfused disconnect switches (indicated as switches in this section), and separately-enclosed circuit breakers for use in electrical systems rated 600 V and below.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible ground faults.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.
- E. Section 26 24 16, PANELBOARDS: Molded-case circuit breakers.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit the following data for approval:
 - 1) Electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, fuses, circuit breakers, wiring and connection diagrams, accessories, and device nameplate data.
 - 2. Manuals:
 - a. Submit complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering fuses, circuit breakers, and replacement parts.

- 1) Include schematic diagrams, with all terminals identified, matching terminal identification in the enclosed switches and circuit breakers.
- 2) Include information for testing, repair, troubleshooting, assembly, and disassembly.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the enclosed switches and circuit breakers conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the enclosed switches and circuit breakers have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. International Code Council (ICC):
IBC-12 International Building Code
- C. National Electrical Manufacturers Association (NEMA):
FU I-07 Low Voltage Cartridge Fuses
KS I-06 Enclosed and Miscellaneous Distribution Equipment
Switches (600 Volts Maximum)
- D. National Fire Protection Association (NFPA):
70-14 National Electrical Code (NEC)
- E. Underwriters Laboratories, Inc. (UL):
98-07 Enclosed and Dead-Front Switches
248-00 Low Voltage Fuses
489-09 Molded Case Circuit Breakers and Circuit Breaker
Enclosures

PART 2 - PRODUCTS

2.1 FUSED SWITCHES RATED 600 AMPERES AND LESS

- A. Switches shall be in accordance with NEMA, NEC, UL, as specified, and as shown on the drawings.

- B. Shall be NEMA classified General Duty (GD) for 240 V switches, and NEMA classified Heavy Duty (HD) for 480 V switches.
- C. Shall be horsepower (HP) rated.
- D. Shall have the following features:
 - 1. Switch mechanism shall be the quick-make, quick-break type.
 - 2. Copper blades, visible in the open position.
 - 3. An arc chute for each pole.
 - 4. External operating handle shall indicate open and closed positions, and have lock-open padlocking provisions.
 - 5. Mechanical interlock shall permit opening of the door only when the switch is in the open position, defeatable to permit inspection.
 - 6. Fuse holders for the sizes and types of fuses specified.
 - 7. Solid neutral for each switch being installed in a circuit which includes a neutral conductor.
 - 8. Ground lugs for each ground conductor.
 - 9. Enclosures:
 - a. Shall be the NEMA types shown on the drawings.
 - b. Where the types of switch enclosures are not shown, they shall be the NEMA types most suitable for the ambient environmental conditions.
 - c. Shall be finished with manufacturer's standard gray baked enamel paint over pretreated steel.

2.2 UNFUSED SWITCHES RATED 600 AMPERES AND LESS

- A. Shall be the same as fused switches, but without provisions for fuses.

2.3 MOTOR RATED TOGGLE SWITCHES

- A. Type 1, general purpose for single-phase motors rated up to 1 horsepower.
- B. Quick-make, quick-break toggle switch with external reset button and thermal overload protection matched to nameplate full-load current of actual protected motor.

2.4 CARTRIDGE FUSES

- A. Shall be in accordance with NEMA FU 1.
- B. Service Entrance: Class RK1, fast acting.
- C. Feeders: Class RK1, fast acting.
- D. Motor Branch Circuits: Class RK1, time delay.
- E. Other Branch Circuits: Class RK1, time delay.
- F. Control Circuits: Class CC, fast acting.

2.6 SEPARATELY-ENCLOSED CIRCUIT BREAKERS

- A. Provide circuit breakers in accordance with the applicable requirements in Section 26 24 16, PANELBOARDS.
- B. Enclosures shall be the NEMA types shown on the drawings. Where the types are not shown, they shall be the NEMA type most suitable for the ambient environmental conditions.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the manufacturer's instructions, the NEC, as shown on the drawings, and as specified.
- C. Fused switches shall be furnished complete with fuses. Arrange fuses such that rating information is readable without removing the fuses.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - d. Vacuum-clean enclosure interior. Clean enclosure exterior.

3.3 SPARE PARTS

- A. Two weeks prior to the final inspection, furnish one complete set of spare fuses for each fused disconnect switch installed on the project. Deliver the spare fuses to the COTR.

---END---

SECTION 26 41 00 FACILITY LIGHTNING PROTECTION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing and installation of a complete UL master labeled lightning protection system.

1.2 RELATED WORK

- A. Section 07 60 00, FLASHING AND SHEET METAL: Penetrations through the roof.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path to ground for possible ground faults.
- D. Section 26 43 13, SURGE PROTECTIVE DEVICES: Surge protective device installed at the electrical service entrance.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS, (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Show locations of air terminals, connections to required metal surfaces, down conductors, and grounding means.
 - c. Show the mounting hardware and materials used to attach air terminals and conductors to the structure.
 - 2. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the lightning protection system conforms to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the lightning protection system has been properly installed and inspected.

- c. Certification that the lightning protection system has been inspected by a UL representative and has been approved by UL without variation.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. National Fire Protection Association (NFPA):
 - 70-14..... National Electrical Code (NEC)
 - 780-11..... Standard for the Installation of Lightning Protection Systems
- C. Underwriters Laboratories, Inc. (UL):
 - 96-05..... Lightning Protection Components
 - 96A-07..... Installation Requirements for Lightning Protection Systems
 - 467-07..... Standard for Grounding and Bonding Equipment

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Lightning protection components shall conform to NFPA 780 and UL 96, for use on Class I structures. Aluminum materials are not allowed.
 - 1. Class I conductors: Copper.
 - 2. Class I air terminals: Solid copper, 460 mm (18 inches) long, not less than 9.5 mm (3/8 inch) diameter, with sharp nickel-plated points.
 - 4. Ground rods: Copper-clad steel, 0.75 in (19 mm) diameter by 3 m (10 feet) long.
 - 5. Ground plates: Solid copper, not less than 20 gauge.
 - 6. Bonding plates: Bronze, 50 square cm (8 square inches).
 - 7. Through roof connectors: Solid copper riser bar, length and type as required to accommodate roof structure and flashing requirements.
 - 8. Down conductor guards: Stiff copper or brass.
 - 9. Anchors and fasteners: Bronze bolt and clamp type shall be used for all applications except for membrane roof. Adhesive type are allowed only for attachment to membrane roof materials, using adhesive that is compatible with the membrane material.

10. Connectors: Bronze clamp-type connectors shall be used for roof conductor splices, and the connection of the roof conductor to air terminals and bonding plates. Crimp-type connectors are not allowed.
11. Exothermic welds: Exothermic welds shall be used for splicing the roof conductor to the down conductors, splices of the down conductors, and for connection of the down conductors to ground rods, ground plates, and the ground ring.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be coordinated with the roofing manufacturer and installer.
- B. Install the conductors as inconspicuously as practical.
- C. Install the down conductors within the concealed cavity of exterior walls where practical. Run the down conductors to the exterior at elevations below the finished grade.
- D. Where down conductors are subject to damage or are accessible near grade, protect with down conductor guards to 2.4 m (8 feet) above grade. Bond down conductor guards to down conductor at both ends.
- E. Make connections of dissimilar metal with bimetallic type fittings to prevent electrolytic action.
- F. Install ground rods and ground plates not less than 600 mm (2 feet) deep and a distance not less than 900 mm (3 feet) nor more than 2.5 m (8 feet) from the nearest point of the structure. Exothermically weld the down conductors to ground rods and ground plates in the presence of the COTR.
- G. Bond down conductors to metal main water piping where applicable.
- H. Bond down conductors to building structural steel.
- I. Connect roof conductors to all metallic projections and equipment above the roof as indicated on the drawings.
- J. Connect exterior metal surfaces, located within 900 mm (3 feet) of the conductors, to the conductors to prevent flashovers.
- K. Maintain horizontal or downward coursing of main conductor and insure that all bends have at least a 200 mm (8 inches) radius and do not exceed 90 degrees.
- L. Conductors shall be rigidly fastened every 900 mm (3 feet) along the roof and down to the building to ground.
- M. Air terminals shall be secured against overturning either by attachment to the object to be protected or by means of a substantial tripod or other braces permanently and rigidly attached to the building or structure.

- N. Install air terminal bases, cable holders and other roof-system supporting means without piercing membrane or metal roofs.
- O. Use through-roof connectors for penetration of the roof system. Flashing shall be provided by roofing contractor in accordance with Section 07 60 00, FLASHING AND SHEET METAL.
- P. Down conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel or the structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 30 M (100 feet).
- Q. A counterpoise or ground ring, where shown, shall be of No. 1/0 copper cable having suitable resistance to corrosion and shall be laid around the perimeter of the structure in a trench not less than 600 mm (2 feet) deep at a distance not less than 900 mm (3 feet) nor more than 2.5 M (8 feet) from the nearest point of the structure.
- R. On construction utilizing post tensioning systems to secure precast concrete sections, the post tension rods shall not be used as a path for lightning to ground.
- S. Where shown, use the structural steel framework or reinforcing steel as the down conductor.
 - 1. Weld or bond the non-electrically-continuous sections together and make them electrically continuous.
 - 2. Verify the electrical continuity by measuring the ground resistances 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.
 - 3. Connect the air terminals together with an exterior conductor connected to the structural steel framework at not more than 18 m (60 foot) intervals.
 - 4. Install ground connections to earth at not more than 18 m (60 foot) intervals around the perimeter of the building.
 - 5. Weld or braze bonding plates to cleaned sections of the steel and connect the conductors to the plates.
 - 6. Do not pierce the structural steel in any manner. Connections to the structural steel shall conform to UL 96A.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Test the ground resistance to earth by standard methods, and conform to the ground resistance requirements specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

- B. A UL representative shall inspect the lightning protection system. Obtain and install a UL numbered master label for each of the lightning protection systems at the location directed by the UL representative and the COTR.

---END---

SECTION 26 43 13 SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of Type 2 Surge Protective Devices, as defined in NFPA 70, and indicated as transient voltage surge suppression or TVSS in this section.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- B. Section 26 24 16, PANELBOARDS: For factory-installed or external TVSS.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Include electrical ratings and device nameplate data.
 - 2. Manuals:
 - a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
 - 3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the TVSS conforms to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the TVSS has been properly installed.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplement and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.
- B. Institute of Engineering and Electronic Engineers (IEEE):
 - IEEE C62.41.2-02 Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
 - IEEE C62.45-03 Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits
- C. National Fire Protection Association (NFPA):
 - 70-14 National Electrical Code (NEC)
- D. Underwriters Laboratories, Inc. (UL):
 - UL 1283-05 Electromagnetic Interference Filters
 - UL 1449-06 Surge Protective Devices

PART 2 - PRODUCTS

2.2 PANELBOARD TVSS

- A. General Requirements:
 - 1. Comply with UL 1449 and IEEE C62.41.2.
 - 2. Modular design with field-replaceable modules, or non-modular design.
 - 3. Fuses, rated at 200 kA interrupting capacity.
 - 4. Bolted compression lugs for internal wiring.
 - 5. Integral disconnect switch.
 - 6. Redundant suppression circuits.
 - 7. LED indicator lights for power and protection status.
 - 8. Audible alarm, with silencing switch, to indicate when protection has failed.
 - 9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
 - 10. Four-digit transient-event counter.
- B. Surge Current per Phase: Minimum 120kA per phase.

2.3 ENCLOSURES

- A. Enclosures: NEMA 1 and 3R.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Factory-installed TVSS: Panelboard manufacturer shall install TVSS at the factory.
- B. Field-installed TVSS: Contractor shall install TVSS with conductors or buses between TVSS and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
 - 1. Provide a circuit breaker as a dedicated disconnecting means for TVSS as shown on drawings.
- C. Do not perform insulation resistance tests on panelboards, or feeders with the TVSS connected. Disconnect TVSS before conducting insulation resistance tests, and reconnect TVSS immediately after insulation resistance tests are complete.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify that disconnecting means and feeder size and maximum length to TVSS corresponds to approved shop drawings.
 - d. Verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - e. Vacuum-clean enclosure interior. Clean enclosure exterior.
 - f. Verify the correct operation of all sensing devices, alarms, and indicating devices.

3.3 FOLLOW-UP VERIFICATION

- A. After completion of acceptance checks and tests, the Contractor shall show by demonstration in service that TVSS are in good operating condition and properly performing the intended function.

3.4 INSTRUCTION

- A. Provide the services of a factory-trained technician for one 2-hour training period for instructing personnel in the maintenance and operation of the TVSS, on the date requested by the COTR.

---END---

SECTION 26 51 00 INTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies the furnishing, installation, and connection of the interior lighting systems. The terms "lighting fixture," "fixture," and "luminaire" are used interchangeably.

1.2 RELATED WORK

- A. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT: Disposal of lamps.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- C. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- E. Section 26 27 26, WIRING DEVICES: Wiring devices used for control of the lighting systems.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit the following information for each type of lighting fixture designated on the LIGHTING FIXTURE SCHEDULE, arranged in order of lighting fixture designation.
 - b. Material and construction details, include information on housing and optics system.
 - c. Physical dimensions and description.
 - d. Wiring schematic and connection diagram.
 - e. Installation details.
 - f. Energy efficiency data.

- g. Photometric data based on laboratory tests complying with IES Lighting Measurements testing and calculation guides.
 - h. Lamp data including lumen output (initial and mean), color rendition index (CRI), rated life (hours), and color temperature (degrees Kelvin).
 - i. Ballast data including ballast type, starting method, ambient temperature, ballast factor, sound rating, system watts, and total harmonic distortion (THD).
 - j. For LED lighting fixtures, submit US DOE LED Lighting Facts label, and IES L70 rated life.
2. Manuals:
- a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
- a. Certification by the Contractor that the interior lighting systems have been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American National Standards Institute (ANSI):
 - C78.1-91 Fluorescent Lamps - Rapid-Start Types - Dimensional and Electrical Characteristics
 - C78.376-01 Chromaticity of Fluorescent Lamps
- C. American Society for Testing and Materials (ASTM):
 - C635-07 Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings
- D. Environmental Protection Agency (EPA):
 - 40 CFR 261 Identification and Listing of Hazardous Waste
- E. Federal Communications Commission (FCC):
 - CFR Title 47, Part 15..... Radio Frequency Devices

CFR Title 47, Part 18..... Industrial, Scientific, and Medical Equipment

F. Illuminating Engineering Society (IES):

LM-79-08..... Electrical and Photometric Measurements of Solid-State
Lighting Products

LM-80-08..... Measuring Lumen Maintenance of LED Light Sources

LM-82-12..... Characterization of LED Light Engines and LED Lamps for
Electrical and Photometric Properties as a Function of
Temperature

G. Institute of Electrical and Electronic Engineers (IEEE):

C62.41-91 Surge Voltages in Low Voltage AC Power Circuits

H. International Code Council (ICC):

IBC-12..... International Building Code

I. National Fire Protection Association (NFPA):

70-11 National Electrical Code (NEC)

101-12..... Life Safety Code

J. National Electrical Manufacturer's Association (NEMA):

SSL-1-10..... Electronic Drivers for LED Devices, Arrays, or Systems

K. Underwriters Laboratories, Inc. (UL):

496-08..... Lampholders

844-12..... Luminaires for Use in Hazardous (Classified) Locations

924-12..... Emergency Lighting and Power Equipment

1598-08..... Luminaires

2108-04..... Low-Voltage Lighting Systems

8750-09..... Light Emitting Diode (LED) Light Sources for Use in Lighting Products

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES

- A. Shall be in accordance with NFPA, UL, as shown on drawings, and as specified.
- B. Sheet Metal:
 - 1. Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved), and parallel to each other as designed.
 - 2. Wireways and fittings shall be free of burrs and sharp edges, and shall accommodate internal and branch circuit wiring without damage to the wiring.
 - 3. When installed, any exposed fixture housing surface, trim frame, door frame, and lens frame shall be free of light leaks.

4. Hinged door frames shall operate smoothly without binding. Latches shall function easily by finger action without the use of tools.
- C. Recessed fixtures mounted in an insulated ceiling shall be listed for use in insulated ceilings.
- D. Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, aircraft cable, captive hinges, or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.
- E. Metal Finishes:
 1. The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion-resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking, and shall be applied after fabrication.
 2. Interior light reflecting finishes shall be white with not less than 85 percent reflectances, except where otherwise shown on the drawing.
 3. Exterior finishes shall be as shown on the drawings.
- F. Lighting fixtures shall have a specific means for grounding metallic wireways and housings to an equipment grounding conductor.
- G. Lighting fixtures in hazardous areas shall be suitable for installation in Class and Division areas as defined in NFPA 70.

2.2 EMERGENCY LIGHTING UNIT

- A. Complete, self-contained unit with batteries, battery charger, one or more local or remote lamp heads with lamps, under-voltage relay, and test switch.
 1. Enclosure: Shall be cast aluminum. Enclosure shall be suitable for the environmental conditions in which installed.
 2. Lamp Heads: Horizontally and vertically adjustable, mounted on the face of the unit, except where otherwise indicated.
 3. Lamps: Shall be sealed-beam MR-16 halogen, rated not less than 12 watts at the specified DC voltage.
 4. Battery: Shall be maintenance-free nickel-cadmium. Minimum normal life shall be minimum of 10 years.

5. Battery Charger: Dry-type full-wave rectifier with charging rates to maintain the battery in fully-charged condition during normal operation, and to automatically recharge the battery within 12 hours following a 1-1/2 hour continuous discharge.
6. Integral Self-Test: Automatically initiates test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing LED.

2.3 LED EXIT LIGHT FIXTURES

- A. Exit light fixtures shall meet applicable requirements of NFPA and UL.
- B. Housing and door shall be die-cast aluminum.
- C. For general purpose exit light fixtures, door frame shall be hinged, with latch. For vandal-resistant exit light fixtures, door frame shall be secured with tamper-resistant screws.
- D. Finish shall be satin or fine-grain brushed aluminum.
- E. There shall be no radioactive material used in the fixtures.
- F. Fixtures:
 1. Inscription panels shall be cast or stamped aluminum a minimum of 2.25 mm (0.090 inch) thick, stenciled with 150 mm (6 inch) high letters, baked with red color stable plastic or fiberglass. Lamps shall be luminous Light Emitting Diodes (LED) mounted in center of letters on red color stable plastic or fiberglass.
 2. Double-Faced Fixtures: Provide double-faced fixtures where required or as shown on drawings.
 3. Directional Arrows: Provide directional arrows as part of the inscription panel where required or as shown on drawings. Directional arrows shall be the "chevron-type" of similar size and width as the letters and meet the requirements of NFPA 101.
- G. Voltage: Multi-voltage (120 – 277V).

2.4 LED LIGHT FIXTURES

- A. General:
 1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.
 2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.
 3. LED drivers shall include the following features unless otherwise indicated:
 - a. Minimum efficiency: 85% at full load.
 - b. Minimum Operating Ambient Temperature: -20° C. (-4° F.)
 - c. Input Voltage: 120 - 277V (±10%) at 60 Hz.

- d. Integral short circuit, open circuit, and overload protection.
 - e. Power Factor: ≥ 0.95 .
 - f. Total Harmonic Distortion: $\leq 20\%$.
 - g. Comply with FCC 47 CFR Part 15.
4. LED modules shall include the following features unless otherwise indicated:
- a. Comply with IES LM-79 and LM-80 requirements.
 - b. Minimum CRI 80 and color temperature 3000° K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
 - c. Minimum Rated Life: 50,000 hours per IES L70.
 - d. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.
- B. LED Downlights:
- 1. Housing, LED driver, and LED module shall be products of the same manufacturer.
- C. LED Troffers:
- 1. LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling.
 - 2. Housing, LED driver, and LED module shall be products of the same manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC, manufacturer's instructions, and as shown on the drawings or specified.
- B. Align, mount, and level the lighting fixtures uniformly.
- C. Wall-mounted fixtures shall be attached to the studs in the walls, or to a 20 gauge metal backing plate that is attached to the studs in the walls. Lighting fixtures shall not be attached directly to gypsum board.
- D. Lighting Fixture Supports:
 - 1. Shall provide support for all of the fixtures. Supports may be anchored to channels of the ceiling construction, to the structural slab or to structural members within a partition, or above a suspended ceiling.
 - 2. Shall maintain the fixture positions after cleaning and relamping.
 - 3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.
- E. Furnish and install the new lamps as specified for all lighting fixtures installed under this project, and for all existing lighting fixtures reused under this project.

- F. The electrical and ceiling trades shall coordinate to ascertain that approved lighting fixtures are furnished in the proper sizes and installed with the proper devices (hangers, clips, trim frames, flanges, etc.), to match the ceiling system being installed.
- G. Bond lighting fixtures to the grounding system as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- H. At completion of project, replace all defective components of the lighting fixtures at no cost to the Government.
- I. Dispose of lamps per requirements of Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform the following:
 - 1. Visual Inspection:
 - a. Verify proper operation by operating the lighting controls.
 - b. Visually inspect for damage to fixtures, lenses, reflectors, diffusers, and louvers. Clean fixtures, lenses, reflectors, diffusers, and louvers that have accumulated dust, dirt, or fingerprints during construction.
 - 2. Electrical tests:
 - a. Exercise dimming components of the lighting fixtures over full range of dimming capability by operating the control devices(s) in the presence of the COTR. Observe for visually detectable flicker over full dimming range, and replace defective components at no cost to the Government.
 - b. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Government. Burn-in period to be 40 hours minimum, unless specifically recommended otherwise by the lamp manufacturer. Burn-in dimmed fluorescent and compact fluorescent lamps for at least 100 hours at full voltage, unless specifically recommended otherwise by the lamp manufacturer. Replace any lamps and ballasts which fail during burn-in.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the lighting systems are in good operating condition and properly performing the intended function.

---END---

SECTION 26 56 00 EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation, and connection of exterior fixtures, poles, and supports. The terms "lighting fixtures", "fixture" and "luminaire" are used interchangeably.

1.2 RELATED WORK

- A. Section 03 30 00, CAST-IN-PLACE CONCRETE.
- B. Section 09 06 00, SCHEDULE FOR FINISHES: Finishes for exterior light poles and luminaires.
- C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- D. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage power and lighting wiring.
- E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- F. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits, fittings, and boxes for raceway systems.
- G. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Underground handholes and conduits.
- H. Section 26 09 23, LIGHTING CONTROLS: Controls for exterior lighting.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit the following information for each type of lighting fixture designated on the LIGHTING FIXTURE SCHEDULE, arranged in order of lighting fixture designation.

- b. Material and construction details, include information on housing and optics system.
 - c. Physical dimensions and description.
 - d. Wiring schematic and connection diagram.
 - e. Installation details.
 - f. Energy efficiency data.
 - g. Photometric data based on laboratory tests complying with IES Lighting Measurements testing and calculation guides.
 - h. Lamp data including lumen output (initial and mean), color rendition index (CRI), rated life (hours), and color temperature (degrees Kelvin).
 - i. Ballast data including ballast type, starting method, ambient temperature, ballast factor, sound rating, system watts, and total harmonic distortion (THD).
 - j. For LED lighting fixtures, submit US DOE LED Lighting Facts label, and IES L70 rated life.
 - k. Submit site plan showing all exterior lighting fixtures with fixture tags consistent with Lighting Fixture Schedule as shown on drawings. Site plan shall show computer generated point-by-point illumination calculations. Include lamp lumen and light loss factors used in calculations.
2. Manuals:
- a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
- a. Certification by the Contractor that the exterior lighting systems have been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. Aluminum Association Inc. (AA):
AAH35.1-06..... Alloy and Temper Designation Systems for Aluminum

- C. American Association of State Highway and Transportation Officials (AASHTO):
 - 32-LTS-6 Structural Supports for Highway Signs, Luminaires and Traffic Signals
- D. American Concrete Institute (ACI):
 - 318-05 Building Code Requirements for Structural Concrete
- E. American National Standards Institute (ANSI):
 - C81.61-09 Electrical Lamp Bases – Specifications for Bases (Caps) for Electric Lamps
- F. American Society for Testing and Materials (ASTM):
 - A123/A123M-12 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - A153/A153M-09 Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - B108-03a-08 Aluminum-Alloy Permanent Mold Castings
 - C1089-13 Spun Cast Prestressed Concrete Poles
- G. Federal Aviation Administration (FAA):
 - AC 70/7460-IK-07..... Obstruction Lighting and Marking
 - AC 150/5345-43F-06..... Obstruction Lighting Equipment
- H. Illuminating Engineering Society of North America (IESNA):
 - HB-9-00..... Lighting Handbook
 - RP-8-05..... Roadway Lighting
 - LM-52-03..... Photometric Measurements of Roadway Sign Installations
 - LM-72-10..... Directional Positioning of Photometric Data
 - LM-79-08..... Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products
 - LM-80-08..... Approved Method for Measuring Lumen Maintenance of LED Light Sources
 - TM-15-07..... Backlight, Uplight and Glare (BUG) Ratings
- I. National Electrical Manufacturers Association (NEMA):
 - ICS 2-00 (R2005) Controllers, Contactors and Overload Relays Rated 600 Volts
 - ICS 6-93 (R2006) Enclosures
- J. National Fire Protection Association (NFPA):
 - 70-11 National Electrical Code (NEC)

- K. Underwriters Laboratories, Inc. (UL):
 - 496-08 Lampholders
 - 773-95 Plug-In, Locking Type Photocontrols for Use with Area Lighting
 - 773A-06 Nonindustrial Photoelectric Switches for Lighting Control
 - 1598-08 Luminaires
 - 8750-09.....Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.6 DELIVERY, STORAGE, AND HANDLING

Provide manufacturer's standard provisions for protecting pole finishes during transport, storage, and installation. Do not store poles on ground. Store poles so they are at least 305 mm (12 inches) above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

Luminaires, materials and equipment shall be in accordance with NEC, UL, ANSI, and as shown on the drawings and specified.

2.4 LUMINAIRES

- A. Luminaires shall be weatherproof, heavy duty, outdoor types designed for efficient light utilization, adequate dissipation of lamp and ballast heat, and safe cleaning and relamping.
- B. Illumination distribution patterns, BUG ratings and cutoff types as defined by the IESNA shall be as shown on the drawings.
- C. Incorporate drivers or ballasts in the luminaire housing, except where otherwise shown on the drawings.
- D. Lenses shall be frame-mounted, heat-resistant, borosilicate glass, with prismatic refractors, unless otherwise shown on the drawings. Attach the frame to the luminaire housing by hinges or chain. Use heat and aging-resistant, resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- E. Pre-wire internal components to terminal strips at the factory.
- F. Bracket-mounted luminaires shall have leveling provisions and clamp-type adjustable slip-fitters with locking screws.
- G. Materials shall be rustproof. Latches and fittings shall be non-ferrous metal.
- H. Provide manufacturer's standard finish, as scheduled on the drawings. Where indicated on drawings, match finish process and color of pole or support materials. Where

indicated on drawings, provide finishes as indicated in Section 09 06 00, SCHEDULE FOR FINISHES.

- I. Luminaires shall carry factory labels, showing complete, specific lamp and ballast information.

2.5 LAMPS

- A. Install the proper lamps in every luminaire installed as shown on the drawings.
- B. LED sources shall meet the following requirements:
 1. Operating temperature rating shall be between -40 degrees C (-40 degrees F) and 50 degrees C (120 degrees F).
 2. Correlated Color Temperature (CCT): 4000K.
 3. Color Rendering Index (CRI): ≥ 85 .
 4. The manufacturer shall have performed reliability tests on the LEDs luminaires complying with Illuminating Engineering Society (IES) LM79 for photometric performance and LM80 for lumen maintenance and L70 life.
- C. Mercury vapor lamps shall not be used.

2.9 LED DRIVERS

- A. LED drivers shall meet the following requirements:
 1. Drivers shall have a minimum efficiency of 85%.
 2. Starting Temperature: -40 degrees C (-40 degrees F).
 3. Input Voltage: 120 to 480 ($\pm 10\%$) volt.
 4. Power Supplies: Class I or II output.
 5. Surge Protection: The system must survive 250 repetitive strikes of "C Low" (C Low: 6kV/1.2 x 50 μ s, 10kA/8 x 20 μ s) waveforms at 1-minute intervals with less than 10% degradation in clamping voltage. "C Low" waveforms are as defined in IEEE/ASNI C62.41.2-2002, Scenario 1 Location Category C.
 6. Power Factor (PF): ≥ 0.90 .
 7. Total Harmonic Distortion (THD): $\leq 20\%$.
 8. Comply with FCC Title 47 CFR Part 18 Non-consumer RFI/EMI Standards.
 9. Drivers shall be reduction of hazardous substances (ROHS)-compliant.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lighting in accordance with the NEC, as shown on the drawings, and in accordance with manufacturer's recommendations.
- B. Adjust luminaires that require field adjustment or aiming.

3.2 GROUNDING

Ground noncurrent-carrying parts of equipment, including metal poles, luminaires, mounting arms, brackets, and metallic enclosures, as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS. Where copper grounding conductor is connected to a metal other than copper, provide specially-treated or lined connectors suitable and listed for this purpose.

3.3 ACCEPTANCE CHECKS AND TESTS

Verify operation after installing luminaires and energizing circuits.

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