

SECTION 26 05 01 ELECTRICAL GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Electrical General Requirements, as shown on the Plans, as specified and/or directed.

1.02 REFERENCES:

- A. The publications listed below and their latest revisions form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only.
 - 1. Federal Specification (Fed. Spec.):
 - a. L-P-387A - Plastic Sheet, Laminated, Thermosetting (for Design Plates)
 - 2. American National Standards Institute (ANSI) Publications:
 - a. C37.20 - Switchgear Assemblies, Including Metal-Enclosed Bus
 - b. Z35.1 - Accident Prevention Signs
 - 3. Institute of Electrical and Electronics Engineers (IEEE) Publication:
 - a. 100 - Standard Dictionary of Electrical and Electronics Terms
 - 4. National Electrical Manufacturers Association (NEMA) Publication:
 - a. ICS 6 - Enclosures for Industrial Controls and Systems
 - 5. National Fire Protection Association (NFPA) Publications:
 - a. 70B - Electrical Equipment Maintenance
 - b. 70 - National Electrical Code

1.03 APPLICATION:

- A. This Section applies to all sections of Division 26, "Electrical", of this project except as specified otherwise in each individual section.

1.04 DEFINITION OF ELECTRICAL TERMS:

- A. Unless otherwise specified or indicated, electrical terms used in these Specifications, and on the drawings, shall be as defined in IEEE Standard No. 100.

1.05 ELECTRICAL UTILITY COORDINATION & ELECTRICAL SYSTEM VERIFICATION:

- A. Contractor shall coordinate all pre and post construction activities with the Electrical Utility (EU) provider per the EUs written bulletin/specification requirements.
- B. Prior to shop drawing submittals, prior to commencing any demolition and/or prior to commencing any new construction activities, electrical characteristics for

all existing and/or proposed electrical systems (including service, premises wiring systems and/or separately derived systems) shall be verified by this Contractor.

- C. The Contractor shall coordinate and confirm, in writing, the following information from the Electrical Utility prior to commencement of any work under this Contract:
 - 1. Voltage
 - 2. Number of phases
 - 3. Type of system grounding
 - 4. Metering arrangement and Style
 - 5. Electrical Service Capacity
- D. Should the Contractor's verification of any existing or proposed electrical system indicate a discrepancy with the Contract Documents, report them immediately to the Owner and/or Owners designated representative.
- E. Submitting shop drawings and/or commencing any work under this Contract prior to all electrical systems verification/confirmation as required above signifies that Contractor accepts all existing and proposed electrical system characteristics and conditions.

1.06 SUBMITTALS

- A. Obtain approval before procurement, fabrication, or delivery of items to the job site. Partial submittals will not be acceptable and will be returned without review. Submittals shall include the manufacturer's name, trade name, place of manufacture, catalog model or number, nameplate data, size, layout dimensions, capacity, project specification and paragraph reference, applicable Federal, Military, industry, and technical society publication references, and other information necessary to establish contract compliance of each item to be furnished.
- B. Shop Drawings: In addition to the requirements specified elsewhere, shop drawings shall meet the following requirements. Drawings shall include complete ratings information, wiring diagrams, and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to assure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. If equipment is disapproved, revise drawings to show acceptable equipment and resubmit.
- C. Manufacturer's Data: Submittals for each manufactured item shall be current manufacturer's descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves, and catalog cuts.
- D. Publication Compliance: Where equipment or materials are specified to conform to industry and technical society publications of organizations such as American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), and Underwriters' Laboratories Inc. (UL), submit proof of such

compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears. In lieu of the label or listing, submit a certificate from an approved independent testing organization, adequately equipped and competent to perform such services, stating that the item has been tested in accordance with the specified organization's test methods and that the item conforms to the specified organization's publication.

- E. Submittals Required: Supply shop drawing submittal information as otherwise noted in each individual section.
- F. Electronic Shop Drawings Electronic submittals shall be submitted to Engineer in accordance with procedures outlined in these Contract Documents, as established at a preconstruction meeting and/or per Engineer's written instructions.
 - 1. Electronic shop drawings shall be submitted in an OCR (searchable) PDF file format or per Engineer's instructions. Each shop drawing shall be a single electronic file with correct orientation of all sheets contained within.
 - 2. Electronic shop drawings shall be scaled to print at 8.5 inches by 11 inches (for general information, manufacturer's product data, etc.) and as required for drawings (layout drawings, coordination drawings, schematics, site drawings, electronic copy), except as specified otherwise.
 - 3. Engineer shall make final determination on clarity of electronic shop drawings and will reject electronic shop drawing if resolution is not acceptable.

1.07 OPERATION AND MAINTENANCE MANUAL

- A. Submit as required for systems and equipment indicated in the technical sections. Furnish 2 copies, bound in hardback binders or an approved equivalent. Furnish one complete manual prior to performance of systems or equipment tests, and furnish the remaining manuals prior to contract completion. Inscribe the following identification on the cover: the words "OPERATION AND MAINTENANCE MANUAL", the name and location of the system, equipment, building, name of Contractor, and contract number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the system or equipment. Include a table of contents and assemble the manual to conform to the table of contents, with the tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in. The manual shall include:
 - 1. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the system or equipment.
 - 2. A control sequence describing startup, operation, and shutdown.
 - 3. Description of the function of each principal item of equipment.
 - 4. Installation and maintenance instructions.
 - 5. Safety precautions.
 - 6. Diagrams and illustrations.
 - 7. Testing methods.

8. Performance data.
Lubrication schedule including type, grade, temperature range, and frequency.
 9. Parts list. The list shall indicate sources of supply, recommended spare parts, and name of servicing organization.
 10. Appendix: List qualified permanent servicing organizations for support of the equipment, including addresses and certified qualifications.
- B. Electronic Version: Provide a complete O&M as a single PDF file, or multiple files if there are significant amounts of data. PDF file(s) shall be an optical character recognition (OCR) or searchable file.

1.08 SPARE PARTS

- A. Provide spare parts for all equipment installed under this Contract, as indicated in individual specification sections.

1.09 POSTED OPERATING INSTRUCTIONS

- A. Furnish approved operating instructions for systems and equipment indicated in the technical sections for use by operation and maintenance personnel. The operating instructions shall include wiring diagrams, control diagrams, and control sequence for each principal system and equipment. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions as directed. Attach or post operating instructions adjacent to each principal system and equipment including startup, proper adjustment, operating, lubrication, shutdown, safety precautions, procedure in the event of equipment failure, and other items of instruction as recommended by the manufacturer of each system or equipment. Provide weather-resistant materials or weatherproof enclosures for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.10 INSTRUCTION TO OWNER'S PERSONNEL:

- A. Where indicated in the technical sections, furnish the services of competent instructors to give full instruction to Owner's personnel in the adjustment, operation, and maintenance of systems and equipment, including pertinent safety requirements as required. Each instructor shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Owner for regular operation. The number of man days (8 hours) of instruction furnished shall be as specified in each individual section.

1.11 LAYOUT OF THE WORK

- A. Coordinate the proper relation of the work to the building structure, existing utilities and to the work of all trades. Visit the premises and become familiar with the dimensions in the field, and advise the Owner's Representative of any discrepancy before performing any work.

1. Contract Drawings: The Contract Drawings represent the general intent as to layout and equipment arrangements. All locations and dimensions shown shall be field verified and minor alterations made if so required. Where dimensions are not given for the location and arrangement of mechanical systems, locations may be assumed to be approximate, and may be altered if required. Major modifications to the indicated arrangements shall be approved by the Owner's Representative prior to the installation of mechanical systems. Schematic diagrams represent the overall system requirements and do not necessarily indicate the physical orientation, location or dimensions of that system.
2. Record Drawings: The Contractor shall maintain a record of the progress of the work and shall submit three (3) hard copy sets of As-Built Drawings upon completion of the project.

1.12 DELIVERY AND STORAGE

- A. Handle, store, and protect equipment and materials in accordance with the manufacturer's recommendations and with the requirements of NFPA 70B, Appendix I, titled "Equipment Storage and Maintenance During Construction". Replace damaged or defective items with new items.

1.13 SPECIAL CONDITIONS

- A. When performing work within active museum and office areas, the Contractor shall be responsible to coordinate with the Owner regarding planned interruptions to electrical services and/or road access. Contractor must maintain in service the existing electrical services at the existing museum unless otherwise coordinated with the Owner.
- B. Protection of Existing Work: The Contractor shall take all necessary precautions to ensure against damage to existing work to remain in place, or to be reused. The Contractor shall ensure that structural elements are not overloaded and additional structural supports required as a result of any cutting, removal or demolition work performed under any part of this Contract are added. Unless specified otherwise, the Contractor shall submit for review detailed shop drawings applicable to the Contract work for all structural supports, hangers and related devices, structural modifications, temporary rigging and associated rigging plans. Commencement of such work prior to the submission and review of applicable shop drawings shall be at the sole risk of the Contractor.
- C. Upon damage to existing equipment, buildings, and/or structures, the Contractor shall immediately notify the Owner. All damages shall be repaired by the Contractor, or shall be replaced if beyond repair, to match the existing to the Owner's satisfaction.
- D. Protection of Buildings from the Weather: The interior of the buildings and all materials and equipment shall be protected from the weather at all times.
- E. Protection of Personnel: Where the safety of non-contractor personnel is endangered in the area of the work, barricades shall be used. Additional

protection shall be provided if required, to preserve the safety of non-contractor personnel in the immediate area of the work.

- F. Contractor shall maintain open road access at all times to the existing museum. Contractor shall stage construction such that at least one lane of the existing access road is open at all times. Contractor shall coordinate with the Owner a minimum of one week prior to any planned road closings.
- G. Construction in Existing Buildings: Verify with Owner expected routing of new wire and/or conduit within existing equipment or buildings prior to field construction of systems. Coordinate with the Owner a minimum of ten (10) working days prior to any planned disruption of existing working systems.

1.14 CATALOGED PRODUCTS/SERVICE AVAILABILITY:

- A. Materials and equipment shall be current products by manufacturers regularly engaged in the production of such products. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The 2-year period shall be satisfactorily completed by a product for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished. The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the Contract.

1.15 MANUFACTURER'S RECOMMENDATIONS:

- A. Where installation procedures or any part thereof are required to be in accordance with manufacturer's recommendations, furnish printed copies of the recommendations prior to installation. Installation of the item shall not proceed until recommendations are received. Failure to furnish recommendations shall be cause for rejection of the equipment or material. Obtain manufacturer's recommendations from the Owner for equipment and/or material provided by the Owner.

1.16 MOTORS AND MOTOR CONTROLS FOR MECHANICAL EQUIPMENT:

- A. The electrical components of mechanical equipment, such as motors, motor starters, control or push button stations, float or pressure switches, solenoid valves, and other devices functioning to control mechanical equipment, and control wiring and conduit for circuits rated 100 volts or less, are specified in the section covering the associated mechanical equipment, rather than in Division 26, unless otherwise shown. The interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit, and the electrical power circuits shall be furnished and installed under Division 26 in accordance with other sections and/or as shown on the Contract Drawings.

1.17 ARC FLASH HAZARD ANALYSIS

- A. Unless specified elsewhere in these Contract Documents, provide arc-flash analysis and labels on all Contractor provided and/or installed: switchboards, panelboards, meter trough's MCCs, motor controllers and disconnects.
- B. The ARC flash hazard analysis shall provide the following system information: System voltage, hazard and risk category, flash protection boundary, shock approach boundaries, required level of pipe, equipment ID, and date of assessment. Table 130.7(c)(15)(a) and 130.7(c)(15)(b) from NFPA 70E (most recent addition) to be utilized as applicable.
- C. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-LATEST EDITION, Annex D.
- D. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.
- E. The Arc-Flash Hazard Analysis shall include all significant locations from service entrance gear down to and including 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA where work could be performed on energized parts.
- F. Safe working distances shall be based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm^2 .
- G. When appropriate, the short-circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.
- H. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.
- I. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
 2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).
- J. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.
- K. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.
- L. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.
- M. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 Section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.
- N. Provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed. Labels affixed to equipment enclosures rated NEMA 3R, 4, 4X, 6, or 8 shall be rated for outdoor use.
- O. All labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system.
- P. The label shall include the following information, at a minimum:
1. Location designation
 2. Nominal voltage
 3. Flash protection boundary
 4. Hazard risk category
 5. Incident energy (new distribution equipment only)
 6. Working distance
 7. Engineering report number, revision number and issue date.
- Q. Labels shall be machine printed, with no field markings.

- R. For new electrical services: In addition to Arc Flash analysis and labels, provide Available Fault Current analysis and label on service entrance equipment per NEC Article 110.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT:

- A. All materials, equipment, and devices shall, as a minimum, meet the requirements of UL where UL standards are established for those items, and the requirements of NFPA 70. All items shall be new unless specified or indicated otherwise.

2.02 NAMEPLATES

- A. Fed. Spec. L-P-387. Provide laminated plastic nameplates for each panelboard, equipment enclosure, relay, switch, and device. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125-inch thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the black core. Minimum size of nameplates shall be 1.0 inch by 2.5 inches. Lettering shall be a minimum of 0.25-inch high normal block style.
- B. For sites with power generation equipment: Provide permanent nameplate at service entrance equipment indicating type and location of on-site generation power source (generator, PV, co-gen, etc.) in accordance with NEC Article 705. Provide same nameplate at generation sources main disconnect indication type and location of service entrance equipment.

PART 3 - EXECUTION

3.01 NAMEPLATE MOUNTING

- A. Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.
- B. Provide nameplates for all equipment as required by other sections.
- C. Provide nameplates for all owner furnished equipment that is installed by this Contractor.

3.02 PAINTING OF EQUIPMENT

- A. Factory Applied: Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA ICS 6

corrosion-resistance test, except equipment specified to meet requirements of ANSI C37.20 shall have a finish as specified in ANSI C37.20.

3.03 TESTS

- A. General: Perform and record all tests in the presence of the Owner's authorized representative and/or the Engineer. Furnish all instruments and personnel. Perform preliminary tests and correct all defective material and/or workmanship prior to witness of tests. Perform tests as indicated and as otherwise noted in other Sections of the Division 26.
- B. Conduct field tests in the sequence listed below:
 - 1. Insulation Resistance Tests: As required per individual specification sections.
- C. Load Balance Test: Make test by energizing all lighting, motors and other electrical equipment simultaneously for a three-hour period. Alter fuses, circuit breakers, circuit connections, etc., as required for satisfactory performance. Take voltage and amperage readings on each circuit at all panels.
- D. Check the amperage draw, voltage and direction of rotation of each motor in the presence of the equipment contractor and the Owner's representative. Make all necessary changes to obtain proper rotation, motor terminal voltage, motor protection, etc. Revise heater elements as necessary for proper motor protection. Similarly check all other electrically connected equipment.
 - 1. Make the test at a time during the day or night that is mutually satisfactory to the Owner at least one week prior to substantial completion. Make all arrangements and notify all parties in writing at least seventy-two hours prior to the test.
- E. Equipment Operation Test - Show by demonstration in service that all circuits are in good operating condition. Cycle all control equipment under load at least five times.
- F. Equipment and apparatus factory tests - Manufacturer's normal quality control tests are acceptable, unless specific factory witnessed tests are specified in other sections.
- G. Perform all other field tests as required in individual specification sections.

3.04 CLEANING:

- A. When directed, just prior to final acceptance, clean all equipment including, but not limited to, the following:
 - 1. Lighting fixtures, panelboards, control centers, switchgear, receptacles and switch plates - Remove all tags and labels; leave ready for use
 - 2. All equipment to be painted, removing all rust, etc., and leave ready for painting
 - 3. Building, by removing all debris, conduits, wire, insulation, cartons, etc., left as a result of this work.

3.05 THIRD PARTY INSPECTION AND MISC SERVICES COORDINATION

- A. Contractor shall provide and pay for inspection of electrical work by an AHJ approved electrical inspection agency.
- B. Contractor shall coordinate with the Owner and the Internet Provider regarding data service requirements and connection. A new T1 is being provided to the basement of the cottage by others.
- C. Contractor shall coordinate with the Owner regarding connections to existing systems and work within existing buildings and equipment.

3.06 WORK WITHIN EXISTING BUILDINGS

- A. Contractor shall install new feeder breakers in existing panels and shall install new conduit and wire systems within existing buildings. Contractor shall use care in installation of new work and shall protect existing work and finishes in his work area. Contractor shall immediately notify Owner of any damages to existing equipment or finishes and shall restore damaged items to Owner's satisfaction.

END OF SECTION

SECTION 26 05 02 MINOR ELECTRICAL DEMOLITION FOR REMODELING

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Interior demolition, removal and abandonment of interior electrical systems.
- B. Cleaning and repair of existing equipment to remain.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching work: As specified in individual sections.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify field measurements and circuiting arrangements are as shown on drawings.
- B. Verify that abandoned wiring and equipment serve only abandoned facilities.
- C. Demolition drawings are based on casual field observation and existing record documents. Report discrepancies to Engineer before disturbing existing installation.
- D. Beginning of demolition means installer accepts existing conditions.

3.02 PREPARATION

- A. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.
- B. Provide temporary wiring and connections to maintain existing systems in service during construction.
- C. Maintain existing systems in service until new systems are complete and ready for operation. Disable systems only to make switch overs and connections. Closely coordinate interruptions with Owner, providing at least 48 hours notice prior to outages. Minimize outage durations. Such work will normally be performed nights, weekends, or other times when building is not occupied for normal operations.

3.03 DEMOLITION EXISTING ELECTRICAL WORK

- A. Remove existing installations to accommodate requirements for new construction.
- B. Remove abandoned wiring to source of supply, unless otherwise noted on Contract Drawings.
- C. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
- D. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets which are not removed.
- E. Disconnect and remove abandoned panelboards and distribution equipment.
- F. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
- G. Repair adjacent construction and finishes damaged during demolition work.
- H. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.

3.04 CLEANING AND REPAIR

- A. Clean and repair existing materials and equipment which remain or are to be reused.
- B. Panelboards: Clean exposed surfaces and check tightness of electrical connections.
- C. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.

END OF SECTION

SECTION 26 05 19
WIRING/CABLE, 600 VOLTS AND UNDER

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Under this Section, the Contractor shall furnish all labor, materials, equipment and accessories for Wiring/Cable, 600 Volts and Under, as shown on the Plans, as specified and/or directed.
- B. For type MC cable, refer to Contract Drawings for areas where MC cable is allowed. MC cable shall be allowed only for branch circuit wiring (lighting and receptacles) unless otherwise specifically indicated on Contract Drawings.

1.02 REFERENCES

- A. The publications listed below and their latest revisions form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only and shall be the most current version.
 - 1. National Electrical Manufacturers Association (NECA) Publication:
 - a. Standard of Installation
 - 2. International Electrical Testing Association (NETA) Publication:
 - a. ATS - Electrical Power Distribution Equipment and Systems
 - 3. National Fire Protection Association (NFPA) Publication:
 - a. 70 - National Electrical Code
 - 4. American Society for Testing and Materials (ASTM) Publications:
 - a. B1 - Hard-Drawn Copper Wire
 - b. B8 - Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
 - c. E14 - Fire Tests of Through-Penetration Fire Stops
 - 5. Underwriters Laboratories, Inc. (UL) Publications:
 - a. 854 - Service Entrance Cables
 - b. 486A - Wire Connector and Soldering Lugs for Use with Copper Conductors
 - c. 486C - Splicing Wiring Connectors
 - d. 1569 - Metal-Clad Cables

1.03 SUBMITTALS

- A. Product Data: Catalog sheets, specifications and installation instructions.
- B. Specification required test results.

1.04 PRODUCT DELIVERY

- A. Mark and tag insulated conductors and cables for delivery to the site. Include:
 - 1. Contractor's name.

2. Project title and number.
3. Date of manufacture (month & year).
4. Manufacturer's name.
5. Environmental suitability information (listed or marked "sunlight resistant" where exposed to direct rays of sun; wet locations listed/marked for use in wet locations; other applications listed/marked suitable for the applications).

PART 2 - PRODUCTS

2.01 INSULATED CONDUCTORS AND CABLES

- A. Date of Manufacture: No insulated conductor more than one year old when delivered to the site will be acceptable.
- B. Acceptable Companies: American Insulated Wire Corp., BICC General Cable Industries, Inc., Cerro Wire & Cable Co. Inc., Pirelli Cable Corp., Owl Cable Corp., or Southwire Co.
- C. Conductors: Annealed uncoated copper or annealed coated copper in conformance with the applicable standards for the type of insulation to be applied on the conductor. Conductor sizes No. 12 and larger shall be stranded.
- D. Types:
 1. Lighting and Power Wiring:
 - a. Insulation: Unless specified or indicated otherwise or required by NFPA 70, power and lighting wires shall be 600-volt, Type THW, THWN, XHHW, or RHW, except that grounding wire may be Type TW. Where lighting fixtures require 90-degree C conductors, provide only conductors with 90-degree C insulation or better.
 - b. Metal-Clad Cable, NFPA 70 Article 334 Type MC:
 - 1) Interlocked flexible galvanized steel armor sheath, conforming to UL requirements for type MC metal clad cable.
 - 2) Insulated copper conductors, suitable for 600 volts, rated 90°C, one of the types listed in NFPA 70 Table 310-13 or of a type identified for use in Type MC cable.
 - 3) Internal full size copper ground conductor with green insulation.
 - 4) Acceptable Companies: AFC Cable Systems Inc., Coleman Cable Co.
 - 5) Connectors for MC cable: AFC Fitting Inc.'s AFC Series, Arlington Industries Inc.'s Saddle grip, or Thomas & Betts Co.'s Tite-Bite with anti-short bushings.

2. Class 1, 2, 3 Wiring: Minimum size for branch circuits shall be No. 12 AWG; for Class 1 remote-control and signal circuits, No. 14 AWG; and for Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
3. VFD Cables: VFD equipment shall be wired from line side (for standalone VFDs) and load side of VFD (standalone VFDs and MCC VFDs) to motor utilizing VFD rated cable. Cable specifications are as follows:
 - a. 600V UL 1277 Type TC per 2005 NEC Article 336
 - b. Copper Conductors
 - c. Class B Stranding per ASTM
 - d. XLPE Insulation XHHW-2 Rated Circuit Conductors (14 AWG and larger)
 - e. 90°C Wet/Dry
 - f. Class I & II; Division 2 Hazardous Locations
 - g. Overall UL 1685 Vertical Tray Flame Test
 - h. IEEE 1202/383 Vertical Tray Flame Test
 - i. Overall Shield

2.02 CONNECTORS

A. General:

1. Connectors specified are part of a system. Furnish connectors and components, and use specific tools and methods as recommended by connector manufacturer to form complete connector system.
2. Connectors shall be capable of continuous operation at the current rating of the cables on which they are used.
3. Connectors shall be UL 486 A listed, or UL 486 B listed for combination dual rated copper/aluminum connectors (marked AL7CU for 75 degrees C rated circuits and AL9CU for 90 degrees C rated circuits).

B. Splices:

1. Spring Type:
 - a. Rated 105° C, 600V; Buchanan/Ideal Industries Inc.'s B-Cap, Electrical Products Div./3M's Scotchlok Type Y, R, G, B, O/B+, R/Y+, or B/G+, or Ideal Industries Inc.'s Wing Nuts or Wire Nuts.
 - b. Rated 150° C, 600V; Ideal Industries Inc.'s High Temperature Wire-Nut Model 73B, 59B.
2. Indent Type with Insulating Jacket: Rated 105° C, 600V; Buchanan/Ideal Industries Inc.'s Crimp Connectors, Ideal Industries Inc.'s Crimp Connectors, Penn-Union Corp.'s Penn-Crimps, or Thomas & Betts Corp.'s STA-KON.
3. Indent Type (Uninsulated): Anderson/Hubbell's Versa-Crimp, VERSAtile, Blackburn/T&B Corp.'s Color-Coded Compression Connectors, Electrical Products Div./3M's Scotchlok 10000, 11000 Series, Framatome Connectors/Burndy's Hydent, Penn-Union Corp.'s BCU, BBCU Series, or Thomas & Betts Corp.'s Compression Connectors.
4. Connector Blocks: NIS Industries Inc.'s Polaris System, or Thomas & Betts Corp.'s Blackburn AMT Series.

5. Resin Splice Kits: Electrical Products Div./3M's Scotchcast Brand Kit Nos. 82A Series, 82-B1 or 90-B1, or Scotchcast Brand Resin Pressure Splicing Method.
 6. Heat Shrinkable Splices: Electrical Products Div./3M's ITCSN, Raychem Corp.'s Thermofit Type WCS, or Thomas & Betts Corp.'s SHRINK-KON Insulators.
 7. Cold Shrink Splices: Electrical Products Div./3M's 8420 Series.
- C. Gutter Taps: Anderson/Hubbell's GP/GT with GTC Series Covers, Blackburn/T&B Corp.'s H-Tap Type CF with Type C Covers, Framatome Connectors/Burndy's Polytap KPU-AC, H-Crimpit Type YH with CF-FR Series Covers, ILSCO's GTA Series with GTC Series Covers, Ideal Industries Inc.'s Power-Connect GP, GT Series with GIC covers, NSI Industries Inc.'s Polaris System, OZ/Gedney Co.'s PMX or PT with PMXC, PTC Covers, Penn-Union Corp.'s CDT Series, or Thomas & Betts Corp.'s Color-Keyed H Tap CHT with HTC Covers.
- D. Terminals: Nylon insulated pressure terminal connectors by Amp-Tyco/Electronics, Electrical Products Div./3M, Framatome Connectors/Burndy, Ideal Industries Inc., Panduit Corp., Penn-Union Corp., Thomas & Betts Corp., or Wiremold Co.
- E. Lugs:
1. Single Cable (Compression Type Lugs): Copper, 1 or 2 hole style (to suit conditions), long barrel; Anderson/Hubbell's VERSAtile VHCL, Blackburn/T&B Corp.'s Color-Coded CTL, LCN, Framatome Connectors/Burndy's Hylug YA, Electrical Products Div./3M Scotchlok 31036 or 31145 Series, Ideal Industries Inc.'s CCB or CCBL, NSI Industries Inc.'s L, LN Series, Penn-Union Corp.'s BBLU Series, or Thomas & Betts Corp.'s 54930BE or 54850BE Series.
 2. Single Cable (Mechanical Type Lugs): Copper, one or 2 hole style (to suit conditions); Blackburn/T&B Corp.'s Color-Keyed Locktite Series, Framatome Connectors/Burndy's Qiklug Series, NSI Industries Inc.'s Type TL, Penn-Union Corp.'s VI-TITE Terminal Lug Series, or Thomas & Betts Corp.'s Locktite Series.
 3. Multiple Cable (Mechanical Type Lugs): Copper, configuration to suit conditions; Framatome Connectors/Burndy's Qiklug Series, NSI Industries Inc.'s Type TL, Penn-Union Corp.'s VI-TITE Terminal Lug Series, or Thomas & Betts Corp.'s Color-Keyed Locktite Series.

2.03 TAPES

- A. Insulation Tapes:
1. Plastic Tape: Electrical Products Div./3M's Scotch Super 33+ or Scotch 88, Plymouth Rubber Co.'s Plymouth/ Bishop Premium 85CW.
 2. Rubber Tape: Electrical Products Div./3M's Scotch 130C, or Plymouth Rubber Co.'s Plymouth/Bishop W963 Plysafe.

- B. Moisture Sealing Tape: Electrical Products Div./3M's Scotch 2200 or 2210, or Plymouth Rubber Co.'s Plymouth/Bishop 4000 Plyseal-V.
- C. Electrical Filler Tape: Electrical Products Div./3M's Scotchfil, or Plymouth Rubber Co.'s Plymouth/Bishop 125 Electrical Filler Tape.
- D. Color Coding Tape: Electrical Products Div./3M's Scotch 35, or Plymouth Rubber Co.'s Plymouth/Bishop Premium 37 Color Coding.
- E. Arc Proofing Tapes:
 - 1. Arc Proofing Tape: Electrical Products Div./3M's Scotch 77, Mac Products Inc.'s AP Series, or Plymouth Rubber Co.'s Plymouth/Bishop 53 Plyarc.
 - 2. Glass Cloth Tape: Electrical Products Div./3M's Scotch 27/Scotch 69, Mac Products Inc.'s TAPGLA 5066,, or Plymouth Rubber Co.'s Plymouth/Bishop 77 Plyglas.
 - 3. Glass-Fiber Cord: Mac Products Inc.'s MAC 0527.

2.04 WIRE-PULLING COMPOUNDS

- A. To suit type of insulation; American Polywater Corp.'s Polywater Series, Electric Products Div./3M's WL, WLX, or WLW, Greenlee Textron Inc.'s Y-ER-EAS, Cable Cream, Cable Gel, Winter Gel, Ideal Industries Inc.'s Yellow 77, Aqua-Gel II, Aqua-Gel CW, or Thomas & Betts Corp.'s Series 15-230 Cable Pulling Lubricants, or Series 15-631 Wire Slick.

2.05 TAGS

- A. Precision engrave letters and numbers with uniform margins, character size minimum 3/16 inch high.
- B. Phenolic: Two color laminated engraver's stock, 1/16 inch minimum thickness, machine engraved to expose inner core color (white).
- C. Aluminum: Standard aluminum alloy plate stock, minimum .032 inch thick, engraved areas enamel filled or background enameled with natural aluminum engraved characters.

2.06 WIRE MANAGEMENT PRODUCTS

- A. Cable Clamps and Clips, Cable Ties, Spiral Wraps, etc: Catamount/T&B Corp., or Ideal Industries Inc.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install conductors in raceways after the raceway system is completed.

- B. No grease, oil, or lubricant other than wire-pulling compounds specified may be used to facilitate the installation of conductors. Completely and thoroughly swab raceway/wire before installing wire/cable.
- C. All splices and connections shall be made in accessible boxes and cabinets only.

3.02 CIRCUITING

- A. Wiring and cables of different systems shall not be run in same raceway. Power wiring shall not be run in same raceway for remote control/signal wiring.
- B. Class 2, 3 plenum rated cables shall be run without raceway when concealed above accessible ceilings unless otherwise indicated on Contract Drawings. These cables shall be run parallel and perpendicular to building surfaces, and shall be neatly bundled and shall be supported independently from the accessible ceiling utilizing bridle rings or similar. Cables shall effectively be routed horizontal. Provide conduit sleeves at wall penetrations.

3.03 COMMON NEUTRAL CONDUCTOR

- A. A common neutral shall not be used. Provide individual neutral per each circuit.

3.04 COLOR CODING

- A. Color Coding for 120/208/240 Volt Electric Light and Power Wiring:
 - 1. Color Code:
 - a. 2 wire circuit - black, white.
 - b. 3 wire circuit - black, red, white.
 - c. 4 wire circuit - black, red, blue, white.
 - 2. White to be used only for an insulated grounded conductor (neutral). If neutral is not required use black and red, or black, red and blue for phase to phase circuits.
 - a. "White" for Sizes No. 6 AWG or Smaller:
 - 1) Continuous white outer finish, or:
 - 2) Three continuous white stripes on other than green insulation along its continuous length.
 - b. "White" for Sizes Larger Than No. 6 AWG:
 - 1) Continuous white outer finish, or:
 - 2) Three continuous white stripes on other than green insulation along its continuous length, or:
 - 3) Distinctive white markings (color coding tape) encircling the conductor, installed on the conductor at time of its installation. Install white color coding tape at terminations, and at 1' 0" intervals in gutters, pull boxes, and manholes.
 - 3. Colors (Black, Red, Blue):
 - a. For Branch Circuits: Continuous color outer finish.
 - b. For Feeders:
 - 1) Continuous color outer finish, or:

- 2) Color coding tapes encircling the conductors, installed on the conductors at time of their installation. Install color coding tapes at terminations, and at 1' 0" intervals in gutter, pull boxes, and manholes.
- B. More Than One Nominal Voltage System Within A building: Permanently post the color coding scheme at each branch-circuit panelboard.
- C. Existing Color Coding Scheme: Where an existing color coding scheme is in use, match the existing color coding if it is in accordance with the requirements of NFPA 70.
- D. Color Code For Wiring Other Than Light and Power: In accordance with ICEA/NEMA WC-30 "Color Coding of Wires and Cables". Other coding methods may be used, as approved.
- E. On 3-phase, 4-wire delta system, high leg shall be orange, as required by NFPA 70.

3.05 IDENTIFICATION

- A. Identification Tags: Use tags to identify feeders and designated circuits. Install tags so that they are easily read without moving adjacent feeders or requiring removal of arc proofing tapes. Attach tags with non-ferrous wire or brass chain.
 1. Interior Feeders: Identify each feeder in pull boxes and gutters. Identify by feeder number and size.
 2. Exterior Feeders: Identify each feeder in manholes and in interior pull boxes and gutters. Identify by feeder number and size, and also indicate building number and panel designation from which feeder originates.
 3. Street and Grounds Lighting Circuits: Identify each circuit in manholes and lighting standard bases. Identify by circuit number and size, and also indicate building number and panel designation from which circuit originates.
- B. Identification Plaque: Where a building or structure is supplied by more than one service, or has any combination of feeders, branch circuits, or services passing through it, install a permanent plaque or directory at each service, feeder and branch circuit disconnect location denoting all other services, feeders, or branch circuits supplying that building or structure or passing through that building or structure and the area served by each.
- C. All control conductors as specified herein shall be labeled at each termination point. Labeling shall be permanently labeled with printed Brady type labels or equivalent.

3.06 WIRE MANAGEMENT

- A. Use wire management products to bundle, route, and support wiring in junction boxes, pull boxes, wireways, gutters, channels, and other locations where wiring is accessible.

3.07 EQUIPMENT GROUNDING CONDUCTOR

- A. Install Equipment Grounding Conductor:
 - 1. Where specified in other Sections or indicated on the Contract Drawings.
 - 2. In conjunction with circuits recommended by equipment manufacturers to have equipment grounding conductor.
- B. Equipment grounding conductor is not intended as a current carrying conductor under normal operating circumstances.
- C. Color Coding For Equipment Grounding Conductor:
 - 1. Color Code: Green.
 - 2. "Green" For sizes No. 6 AWG or Smaller:
 - a. Continuous green outer finish, or:
 - b. Continuous green outer finish with one or more yellow stripes, or:
 - c. Bare copper (see exception below).
 - 3. "Green" For Sizes Larger Than No. 6:
 - a. Stripping the insulation or covering from the entire exposed length (see exception below).
 - b. Marking the exposed insulation or covering with green color coding tapes.
 - c. Identify at each end and at every point where the equipment grounding conductor is accessible.
 - 4. Exception For use of Bare Copper: Not allowed for use where NFPA 70 specifically requires equipment grounding conductor to be insulated, or where specified in other sections or indicated on the drawings to be insulated.

3.08 SPECIAL GROUNDING CONDUCTORS

- A. Technical Power System Grounding (Equipment grounding conductor isolated from the premises grounded conductor except at a single grounded termination point): Install an insulated grounding conductor running with the circuit conductors for isolated receptacles or utilization equipment requiring an isolated ground.
 - 1. Color Code: Green.
 - 2. "Green" For Isolated Grounding Conductor:
 - a. Continuous green outer finish, or:
 - b. Continuous green outer finish with one or more yellow stripes, and:
 - c. Different than the "green" used for the equipment grounding conductor run with the circuit (where required).
 - 3. Install label at every point where the conductor is accessible, identifying it as an "Isolated Grounding Conductor".

3.09 ARC PROOFING

- A. Arc proof 600V and under cables only where routed in a manhole/handhole that also contains medium voltage cable/feeders as follows:

1. Arc proof new 600V and under cables.
2. Arc proof existing 600V and under cables that are spliced to new 600V and under cables.
3. Arc proof each 600V and under cable as a unit (except cables consisting of multiple sets of conductors).
4. Arc proof 600V and under cables consisting of multiple sets of conductors by arc proofing each set of conductors as a unit.
5. Arc proof with half-lapped layer of 55 mils thick arc proofing tape and random wrapped or laced with glass cloth tape or glass-fiber cord. For arc proofing tape less than 55 mils thick, add layers to equivalent of 55 mils thick arc proofing tape.

3.10 INSULATED CONDUCTOR AND CABLE SCHEDULE - TYPES AND USE

- A. Electric Light and Power Circuits:
1. THWN-2 or XHHW-2: Wiring in dry or damp locations (except where special type insulation is required).
 2. XHHW-2: Wiring in wet locations (except where type USE or USE-2 insulated conductors are specifically required, or special type insulation is required).
 3. THWN-2: Wiring installed in existing raceway systems (except where special type insulation is required).
 4. THWN-2 or XHHW-2: Wiring for electric discharge lighting circuits (fluorescent, HID), except where fixture listing requires wiring rated higher than 90° C.
 5. THWN Marked "Gasoline and Oil Resistant": Wiring to gasoline and fuel oil pumps.
 6. MC: Where allowed per the Contract Drawings:
 - a. Branch circuit wiring in wood framed construction (wood joists and wood stud partitions):
 - 1) Install conductors parallel with joists or studs and attach to the side of these timbers by galvanized straps spaced not more than 6 feet apart.
 - 2) Install conductors through holes bored in the center of the timbers when running at right angles to joists or studs.
 - 3) Do not attach the conductors to the edge of joists or studs.
 - b. Branch circuit wiring in movable metal partitions and movable gypsum partitions.
 - 1) Install conductors in accordance with partition manufacturer's recommendations.
 - c. Branch circuit wiring in metal stud partitions:
 - 1) Install conductors parallel with studs and attach to the side by galvanized straps spaced not more than 6 feet apart.
 - 2) Install conductors through holes bored in the center of the metal member when running at right angles to studs.
 - d. Conductors shall be protected by listed bushings or listed grommets covering all metal edges.
 - 1) Do not attach the conductors to the edge of studs.

- B. Class 1 Circuits: Use Class 1 wiring specified in Part 2 (except where special type insulation is required).
- C. Class 2 Circuits: Use Class 2 wiring specified in Part 2 (except where special type insulation is required).
- D. Class 3 Circuits: Use Class 3 wiring specified in Part 2 (except where special type insulation is required).

3.11 CONNECTOR SCHEDULE - TYPES AND USE

- A. Temperature Rating: Use connectors that have a temperature rating, equal to, or greater than the temperature rating of the conductors to which they are connected.
- B. Splices:
 - 1. Dry Locations:
 - a. For Conductors No. 8 AWG or Smaller: Use spring type pressure connectors, indent type pressure connectors with insulating jackets, or connector blocks (except where special type splices are required).
 - b. For Conductors No. 6 AWG or Larger: Use connector blocks or uninsulated indent type pressure connectors. Fill indentions in uninsulated connectors with electrical filler tape and apply insulation tape to insulation equivalent of the conductor, or insulate with heat shrinkable splices or cold shrink splices.
 - c. Gutter Taps in Panelboards: For uninsulated type gutter taps fill indentions with electrical filler tape and apply insulation tape to insulation equivalent of the conductor, or insulate with gutter tap cover.
 - 2. Damp Locations: As specified for dry locations, except apply moisture sealing tape over the entire insulated connection (moisture sealing tape not required if heat shrinkable splices or cold shrink splices are used).
 - 3. Wet Locations: Use uninsulated indent type pressure connectors and insulate with resin splice kits, cold shrink splices or heat shrinkable splices. Exception: Splices aboveground which are totally enclosed and protected in NEMA 3R, 4, 4X enclosures may be spliced as specified for damp locations.
- C. Terminations:
 - 1. For Conductors No. 10 AWG or Smaller: Use terminals for:
 - a. Connecting wiring to equipment designed for use with terminals.
 - 2. For Conductors No. 8 AWG or Larger: Use compression or mechanical type lugs for:
 - a. Connecting cables to flat bus bars.
 - b. Connecting cables to equipment designed for use with lugs.
 - 3. For Conductor Sizes Larger Than Terminal Capacity On Equipment: Reduce the larger conductor to the maximum conductor size that terminal can accommodate (reduced section not longer than one foot). Use

compression or mechanical type connectors suitable for reducing connection.

3.12 TESTING

- A. Insulation Resistance Tests: Make tests after all wiring is completed and connected ready for the attachment of fixture and/or equipment. Repeat test when all fixtures and/or equipment are connected ready for use. Make tests with an instrument capable of measuring the resistance involved at a voltage of at least 500 VDC for equipment rated at 100 to 500 VAC, 1500 VDC for equipment rated at 151 to 600 VAC. Apply voltage continuously for one minute prior to taking reading. Measure insulation resistance between each pair of insulated conductor separately and between each insulated conductor and ground. Make tests at each panelboard distribution panel, and switchboard on every circuit with the circuit protective device open but connected. The minimum acceptable measured insulation resistance for wiring completed and ready for connection of fixtures and/or equipment is 50 meg ohms.

END OF SECTION

SECTION 26 05 26 GROUNDING

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Grounding and bonding of electrical installations as shown on the Plans, as specified and/or directed.
- B. Existing site conditions may necessitate use of alternative grounding systems to achieve required ohm values. Existing site conditions are to include minimum soil cover over bedrock and exposed bedrock.

1.02 REFERENCES

- A. The publications listed below and their latest revisions form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only.
 - 1. American National Standards Institute (ANSI), Electronic Industries Alliance (EIA), Telecommunications Industry Association (TIA)
Publication: (ANSI/EIA/TIA)
 - a. 607 - Commercial Building Grounding and Bonding Requirements for Telecommunications
 - 2. Institute of Electrical and Electronics Engineers (IEEE) Publications:
 - a. 81 - Guide for Measuring Earth Receptivity, Ground Impedance and Earth Surface Potential of a Ground System
 - b. 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems
 - c. 1100 - Recommended Practice for Powering and Grounding Sensitive Electronic Equipment
 - 3. National Fire Protection Association (NFPA) Publication:
 - a. 70 - National Electrical Code (NEC)
 - 4. Underwriters Laboratories, Inc. (UL) Publications:
 - a. 83 - Thermoplastic-Insulated Wires and Cables
 - b. 44 - Rubber-Insulated Wires and Cables
 - c. 467 - Grounding and Bonding Equipment

1.03 SUBMITTALS:

- A. Product Data. Provide data for grounding electrodes and connectors.
- B. Test Reports: Indicate overall resistance to ground.
- C. Manufacturer's Instructions: Include instructions for preparation, installation and examination of exothermic connectors, as applicable.
- D. Certifications: Two weeks prior to final inspection, deliver to the Owner's designated representative four copies of the certification that the material and

installation is in accordance with the drawings and specifications and has been properly installed.

PART 2 - PRODUCTS

2.01 GROUNDING WIRES

- A. General Purpose: UL and NEC approved types, copper, with TW, THW, XHHW or dual rated THHN-THWN insulation color identified green.
- B. Size wire not less than what is shown and not less than required by the NEC.
- C. Stranded bare copper ground conductor where indicated on drawings.

2.02 GROUND RODS

- A. Copper clad steel, 3/4-inch diameter by 10 feet long.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Ground as shown and as hereinafter specified in accordance with the NEC.
- B. System Grounding:
 - 1. Ground the electrical service system neutral at service entrance equipment to grounding electrodes. Concrete encased electrodes shall be connected as the most effective grounding electrodes. Provide a completely grounded system in accordance with Article 250 of the NEC.
 - 2. Ground each separately-derived system neutral to separate grounding electrode system. Transformer, UPS systems, power conditioners, inverters, or other power supplies are separately derived systems. Standby or emergency generators are separately derived systems if the neutral is bonded to the generator frame and if there is no direct connection of the generator neutral conductor to the service neutral conductor.
 - 3. Provide communications system grounding conductor connected to separate electrode (ground bus) that is shall be installed in each IT room. Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, cable trays, auxiliary gutters, meter fittings, boxes, cable armor, cable sheath, ground bus in electrical rooms and IT rooms, metal frame of the building or structure, ground ring, lightning down lead conductor, grounding conductor in raceways and cables, receptacle ground connectors, and metal underground water pipe. Bonding jumpers shall be installed around non-metal fittings or insulating joints to ensure electrical continuity. Bonding shall be provided where necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed.

4. Secondary service neutrals ground at the supply side of the secondary disconnecting means and at the related transformers.
 5. Separately derived systems (transformers downstream from the service entrance) ground the secondary neutral.
 6. Isolation transformers and isolated power systems shall not be system grounded.
- C. Equipment Grounding:
1. Metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits shall be grounded for personnel safety and to provide a low impedance path for possible ground fault currents.

3.02 SECONDARY EQUIPMENT AND CIRCUITS

- A. Main Bonding Jumper: Connect the secondary service neutral to the ground bus in the service equipment.
- B. Water Pipe and Supplemental Electrode:
1. Provide a ground conductor connection between the service equipment ground bus and the metallic water pipe system. Jumper insulating joints/meter in the water pipe.
 2. Provide a supplemental ground electrode and bond to the water pipe ground, or connect to the service equipment ground bus.
 3. Where a new foundation/footer is constructed for a building/structure, the grounding electrode system shall also be bonded to the concrete-encased electrode (reinforcing steel in foundation/ footer). Coordinate with General Contractor.
- C. Service Disconnect (Separate Individual Enclosure): Provide a ground bar bolted to the enclosure with lugs for connecting the various grounding conductors.
- D. Switchgear and Switchboards:
1. Connect the various feeder green grounding conductors to the ground bus in the enclosure with suitable pressure connectors.
 2. Connect the grounding electrode conductor to the ground bus.
 3. Connect the neutral to the ground bus (main bonding jumper).
 4. Connect metallic conduits, which terminate without mechanical connection to the housing, by grounding bushings and ground wire to the ground bus.
- E. Conduit Systems:
1. Ground all metallic conduit systems.
 2. Non-metallic conduit systems shall contain a grounding conductor.
 3. Conduit provided for mechanical protection containing only a grounding conductor, bond to that conductor at the entrance and exit from the conduit.
- F. Feeders and Branch Circuits: Install green grounding conductors with feeders and branch circuits as follows:
1. Feeders.

2. Branch Circuits.
 3. Receptacle Outlets.
 4. Directly Connected Equipment, Appliances and Devices.
 5. Motors and Motor Controllers.
 6. Fixed Equipment and Appurtenances.
 7. Items of equipment where the final connection is made with flexible metal conduit shall have a grounding wire.
 8. Additional locations and systems as shown.
- G. Boxes, Cabinets, Enclosures and Panelboards:
1. Bond the grounding wires to each pull box, junction box, outlet box, cabinets, and other enclosures through which the ground wires pass.
 2. Provide lugs in each box and enclosure for ground wire termination.
 3. Provide ground bars in panelboards, bolted to the housing, with sufficient lugs for terminating the ground wires.
- H. Motors and Starters:
1. Provide lugs in motor terminal box and starter housing for ground wire termination.
 2. Make ground wire connections to ground bus in motor control centers.
- I. Receptacles are not approved for grounding through their mounting screws. Ground with a ground wire from green ground terminal on the receptacle to the outlet box ground screw.
- J. Ground lighting fixtures to the green grounding conductor of the wiring system. During renovation, provide the green ground if it is not part of the system, or ground the fixtures through the conduit systems per means acceptable under the NEC. 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.
- K. Fixed electrical appliances and equipment shall have a ground lug installed for termination of the green ground conductor.

3.03 CONDUCTIVE PIPING

- A. Bond all conductive piping systems in the building to the electrical system ground. Bonding connections shall be made as close as practical to the water pipe ground or service equipment ground bus.

3.04 GROUND RESISTANCE

- A. Grounding system ground resistance must comply with NEC. Provide additional ground rods as required until resistance reading is compliant with NEC.
- B. Services at power company interface points shall comply with the power company ground resistance requirements.

- C. Make necessary modifications to the ground electrodes for compliance that is needed without additional cost to the Owner, including the provisions of a multi-rod system.

3.05 GROUND ROD INSTALLATION

- A. Drive each rod vertically in the earth for not less than ten feet in depth.
- B. Where 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.
- C. Where rock prevents the driving of vertical ground rods, install grounding electrodes in horizontal trenches to achieve the specified resistance.
- D. In manhole, install ground rods with 4 to 6 inches above the floor with connections of grounding conductors fully visible and accessible.

END OF SECTION

SECTION 26 05 34 CONDUIT

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Conduit as shown on the Plans, as specified, and/or directed.

1.02 REFERENCES

- A. The publications listed below and their latest revisions form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only.
 - 1. American National Standards Institute (ANSI) Publications:
 - a. C80.1 - Rigid Steel Conduit, Zinc Coated
 - b. C80.3 - Electrical Metallic Tubing, Zinc Coated
 - c. C80.5 - Rigid Aluminum Conduit
 - 2. National Electrical Manufacturers Association (NEMA) Publications:
 - a. FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies
 - b. RN 1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
 - c. TC 2 - Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
 - d. TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing
 - 3. National Electrical Contractors Association (NECA) Publication:
 - a. Standard of Installation

1.03 SECTION INCLUDES

- A. Rigid steel conduit.
- B. PVC coated rigid steel conduit.
- C. Flexible metal conduit.
- D. Liquid-tight flexible metal conduit.
- E. Electrical metallic tubing.
- F. Nonmetallic conduit.
- G. Flexible nonmetallic conduit.
- H. Electrical nonmetallic tubing.
- I. Fittings and conduit bodies.

1.04 RELATED SECTIONS

- A. Section 26 05 01, "Electrical General Requirements", applies to this Section with additions and modifications specified herein.

1.05 SUBMITTALS:

- A. Conduit and fittings (each type).

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.
- B. Protect PVC conduit from sunlight.

1.07 PROJECT CONDITIONS

- A. Verify that field measurements are as shown on the Contract Drawings.
- B. Verify routing and termination locations of conduit prior to rough-in.
- C. Conduit routing when shown on the Contract Drawings are in approximate locations unless dimensioned. Route as required to complete wiring system.

1.08 QUALITY ASSURANCE

- A. In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" has been substituted for "should" wherever it appears.
- B. Verify routing and termination locations of conduit prior to rough-in.
- C. Conduit routing when shown on the Contract Drawings are in approximate locations unless dimensioned. Route as required to complete wiring system.

1.09 QUALITY ASSURANCE

- A. In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" has been substituted for "should" wherever it appears.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. Materials, equipment, and devices shall, as a minimum, meet requirements of UL, where UL standards are established for these items, and requirements of NFPA 70.

- B. Provide conduit types in specific installations as scheduled on Contract Drawings. Specific conduit material and installation specifications for the scheduled conduit type are specified herein.

2.02 CONDUIT AND FITTINGS

- A. Rigid Steel Conduit (Zinc-coated): ANSI C80.1, UL 6.
- B. Rigid Aluminum Conduit: ANSI C80.5, UL 6.
- C. Rigid Nonmetallic Conduit: UL 651, UL 1684
 - 1. PVC Type EPC-40 and EPC-80, in accordance with NEMA TC2.
 - 2. Fiberglass conduit in accordance with NEMA TC14.
- D. Intermediate Metal Conduit (IMC): UL 1242, zinc-coated steel only.
- E. Electrical Metallic Tubing (EMT): UL 797, ANSI C80.3.
- F. Electrical Nonmetallic Tubing (ENT): NEMA TC13.
- G. Plastic-coated Rigid Steel and IMC Conduit: NEMA RN1, Type 40 (40 mils thick).
- H. Flexible Metal Conduit: UL 1.
 - 1. Liquid-tight Flexible Metal Conduit, Steel: UL 360.
- I. Fittings for Metal Conduit, EMT, and Flexible Metal Conduit: UL 514B. Ferrous fittings shall be cadmium- or zinc-coated in accordance with UL 514B. Fittings shall match conduit type and material.
 - 1. Fittings for Rigid Metal Conduit and IMC: Threaded-type. Split couplings unacceptable.
 - 2. Fittings for EMT: Compression type.
 - 3. Fittings for Use in Hazardous Locations: UL 886.
- J. Fittings for Rigid Nonmetallic Conduit: NEMA TC3. Fittings shall match conduit type and material.

2.03 FIBER OPTIC SYSTEMS

- A. For conduit systems that are intended for the installation of fiber optic cables, all conduit bends radii shall meet or exceed minimum radius in accordance with installed fiber optic bending limitation specifications.
- B. Where conduit bodies are used in 90 degree sections of conduit runs, only "Optical LB", or equivalent shall be used.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Electrical installations shall conform to requirements of NFPA 70 and to requirements specified herein.
- B. Underground Service: Underground service conductors and associated conduit shall be continuous from service entrance equipment to outdoor power system connection.
- C. Service Entrance Identification: Service entrance disconnect devices, switches, or enclosures shall be labeled or identified as such.
 - 1. Labels: Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, each enclosure, new and existing, shall be labeled as one of several enclosures containing service entrance disconnect devices. Label, at minimum, shall indicate number of service disconnect devices housed by enclosure and shall indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels. Use lettering of at least 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure shall be provided only as permitted by NFPA 70.
- D. Wiring Methods: Provide insulated conductors installed in conduit, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Provide insulated, green equipment grounding conductor in feeder and branch circuits, including lighting circuits. Grounding conductor shall be separate from electrical system neutral conductor. Provide insulated, green conductor for grounding conductors installed in conduit or raceways. Minimum conduit size shall be 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings shall be made with metal conduit in fire-rated shafts. Metal conduit shall extend through shafts for minimum distance of 6 inches. Conduit which penetrates fire walls, fire partitions, or floors shall be metallic on both sides of fire walls, fire partitions, or floors for minimum distance of 6 inches.
 - 1. Aluminum Conduit: Do not install underground or encase in concrete. Do not use brass or bronze fittings.
 - 2. Restrictions Applicable to EMT:
 - a. Do not install underground.
 - b. Do not encase in concrete.
 - c. Do not use in areas subject to severe physical damage.
 - d. Do not use in hazardous areas.
 - e. Do not use outdoors.
 - 3. Nonmetallic Conduit: Conduit shall not penetrate fire walls, fire partitions, or floors.
 - 4. ENT: ENT may be provided in walls, floors, and ceilings only when protected by thermal barriers identified as having minimum 15-minute finish rating. If ENT is used, provide required thermal barriers, whether indicated or not.

- a. Following restrictions apply to ENT:
- b. Do not route exposed.
- c. Do not route above suspended ceilings (i.e., between suspended ceilings and permanent ceilings).
- d. Do not use in feeder circuits.
- e. Do not install underground.
- f. Do not encase in concrete.
- g. Do not use in areas subject to severe physical damage including, but not limited to, mechanical equipment rooms, electrical equipment rooms, hospitals, power plants, missile magazines, and other such areas.
- h. Do not use in hazardous areas.
- i. Do not use outdoors.
- j. Do not use in sizes larger than 2 inches.
- k. Do not use in penetrating fire rated walls, partitions, etc.
- 5. Restrictions applicable to PVC Schedule 40 and PVC Schedule 80.
 - a. Do not use in feeder circuits unless otherwise indicated.
 - b. Do not use in areas subject to severe physical damage including, but not limited to, mechanical equipment rooms, electrical equipment rooms, hospitals, power plants, missile magazines, and other such areas.
 - c. Do not use in hazardous areas.
 - d. Do not use in penetrating fire-rated walls or partitions, fire rated floors, etc.
- 6. Service Entrance Conduit, Overhead: Rigid steel or IMC from service entrance to service entrance fitting or weatherhead outside building.
- 7. Service Entrance Conduit, Underground: Galvanized rigid steel or steel IMC. Underground portion shall be encased in minimum of 3 inches of concrete and shall be installed minimum 18 inches below slab or grade.
- 8. Underground Conduit Other Than Service Entrance: Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40; or fiberglass. Convert nonmetallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before rising through floor slab; plastic coating shall extend minimum 6 inches above floor.
- 9. Conduit in Floor Slabs: Rigid steel; steel IMC; fiberglass, or PVC, Type EPC-40.
- 10. Conduit Interior to Buildings for 400 Hz Circuits: Aluminum or nonmetallic. Where 400-Hz circuit runs underground or through concrete, conduit shall be PVC Schedule 80.
- 11. Conduit for Circuits Rated Greater Than 600 Volts: Rigid metal conduit or IMC only.
- E. Conduit Installation: Unless indicated otherwise, conceal conduit within finished walls (existing or proposed), above ceilings, below floors or within floor slabs. With written approval by the Owner's Designated Representative where conduit cannot physically be installed concealed, install decorative surface metal raceway as manufactured by Wiremold Series 2400, or approved equal.
 - 1. For new conduit runs in existing locations, Contractor to field verify all proposed locations prior to installation. Installation of conduit shall be located and installed:
 - a. So as to not interfere with existing utilization equipment.

- b. Not in front of intake/exhaust fans and louvers.
 - c. Not in front of access panels.
 - d. Not in front of doors or windows.
 - e. In a location that does not allow maintenance and clearance to existing and proposed mechanical and electrical equipment
 - f. Not on floor or at a height above floor so as to be a tripping hazard,
 - g. Not installed in dedicated space that would limit an overhead cranes or similar lifting device's ability to remove intended equipment below. This includes but is not limited to access hatches, crane trucks, crane hoists, movement along crane rails, jib crane full swinging arc/areas, etc.
 - 2. Contractor to notify Owner and Owners Designated Representative of all potential conduit installation conflicts with existing equipment, HVAC, plumbing, building or structural systems prior to field construction of conduit systems.
- F. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project. Run conduits in crawl space under slab as if exposed.
- 1. Conduit Through Floor Slabs: Where conduits rise through floor slabs, curved portion of bends shall not be visible above finish slab.
 - 2. Conduit Support: Support conduit by pipe straps, wall brackets, hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Load applied to fasteners shall not exceed one-fourth proof test load. Fasteners attached to concrete ceiling shall be vibration-resistant and shock-resistant. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints shall not cut main reinforcing bars. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended- ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Support exposed risers in wire shafts of multi-story buildings by U-clamp hangers at each floor level and at 10-foot maximum intervals. Where conduit crosses building expansion joints, provide suitable watertight expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. Support raceways within three (3) feet of each outlet box, junction box, cabinet or enclosure.
 - 3. Directional Changes in Conduit Runs: Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

4. Pull Wire: Install pull wires in empty conduits in which wire is to be installed by others. Pull wire shall be plastic having minimum 200-pound tensile strength. Leave minimum 12 inches of slack at each end of pull wire.
5. Telephone and Signal System Conduits: Install in accordance with specified requirements for conduit and with additional requirement that no length of run shall exceed 150 feet for trade sizes 2 inches and smaller and shall not contain more than two 90-degree bends or equivalent. Provide pull or junction boxes where necessary to comply with these requirements. Inside radii of bends in conduits 1-inch trade size and larger shall be minimum five times nominal diameter. Terminate conduit at bottom edge of backboard.
6. Conduit Installed in Concrete Floor Slabs: Locate so as not to adversely affect structural strength of slabs. Install conduit within middle 1/3 of concrete slab. Space conduits horizontally minimum three diameters, except at cabinet locations. Curved portions of bends shall not be visible above finish slab. Increase slab thickness as necessary to provide minimum 1-inch cover over conduit. Where embedded conduits cross expansion joints, provide suitable watertight expansion fittings and bonding jumpers. Conduit larger than 1-inch trade size shall be parallel with or at right angles to main reinforcement; when at right angles to reinforcement, conduit shall be close to one of supports of slab.
7. Locknuts and Bushings: Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use minimum single locknut and bushing. Locknuts shall have sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.
8. Stub-ups: Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 6 inches above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.
9. Flexible Connections: Provide flexible connections of short length, 6-foot maximum, for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Provide liquid-tight flexible conduit in wet locations. Provide separate ground conductor across flexible connections.
10. Arrange conduit to maintain headroom and present neat appearance.
11. Cut conduit square using saw or pipe cutter; deburr cut ends. For field cut threaded conduits, provide field applied anti-corrosion material to the threads in accordance with the manufacturer's instructions and per the NEC. Product shall be Thomas & Betts KOPR-Shield or approved equal.
12. Use conduit hubs or sealing locknuts to fasten conduit to sheet metal boxes in damp and wet locations and to cast boxes.
13. Install no more than equivalent of three 90 degree bends between boxes.
14. Avoid moisture traps; provide junction box with drain fitting at low points in conduit system.

15. Provide suitable fittings to accommodate expansion and deflection where conduit crosses expansion joints.
16. Use suitable caps to protect installed conduit against entrance of dirt and moisture.
17. Ground and bond conduit under as per NEC 250.

3.02 INTERFACE WITH OTHER PRODUCTS

- A. Install conduit to preserve fire resistance rating of partitions and other elements, using materials and methods specified in other sections.
- B. Route conduit through roof openings for piping and ductwork or through suitable roof jack with pitch pocket. Coordinate location with roofing installation. Coordinate installation with representative of roofing material manufacturer to maintain any roof warranty

END OF SECTION

SECTION 26 05 35 OUTLET, JUNCTION AND PULL BOXES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Outlet, Junction and Pull Boxes, as shown on the Plans, as specified, and/or directed.
- B. Plans (drawings) are diagrammatic and show only approximate locations of equipment, fixtures, devices, conduit routing, etc. Plans may not show exact quantity and locations of Junction and Pull Boxes required for a complete installation. Exact locations and routing shall be determined in the field and shall suit the job conditions. Quantities and locations of Outlet, Junction, and Pull Boxes shall be provided to suit the installed arrangement and meet all NEC and local code requirements.

1.02 REFERENCES

- A. NEMA
- B. UL. (Specifically UL 514A)
- C. NFPA 70

1.03 SUBMITTALS

- A. Product Data: Catalog sheets, specifications and installation instructions.
 - 1. For fire rated construction, prove that materials and installation methods proposed for use are in accordance with the listing requirements of the classified construction.
- B. Shop Drawings: Plans, elevations, sections, and details for all custom enclosures and cabinets

1.04 GENERAL REQUIREMENTS

- A. Section 26 05 01, "Electrical General Requirements", applies to this Section, with the additions and modifications specified herein.

PART 2 - PRODUCTS

2.01 GALVANIZED STEEL OUTLET BOXES

- A. Standard galvanized steel boxes and device covers by Appleton Electric Co., Cooper/Crouse-Hinds, Hubbell, or approved equal.

2.02 GALVANIZED STEEL JUNCTION AND PULL BOXES

- A. Code gage, galvanized steel screw cover boxes by Hoffman Enclosures Inc., Hubbell Wiegmann, or approved equal

2.03 THREADED TYPE BOXES

- A. Outlet Boxes: For Dry, Damp Locations: Zinc electroplate malleable iron or cast iron alloy boxes by Appleton Electric Co., Cooper/Crouse-Hinds Co., or approved equal with zinc electroplate steel covers to suit application. For classified spaces, provide outlet boxes rated for Class I, Div. 1, group D hazardous areas as manufactured by Crouse-Hinds, Appleton or approved equal.
- B. For Wet Locations: Malleable iron or cast iron alloy boxes with hot dipped galvanized or other specified corrosion resistant finish as produced by Cooper/Crouse-Hinds (hot dipped galvanized or Corro-free epoxy powder coat), or OZ/Gedney Co. (hot dipped galvanized), with stainless steel cover screws, and malleable iron covers gasketed to suit application.
- C. Junction and Pull Boxes:
 - 1. For Dry, Damp Locations: Zinc electroplate cast iron boxes by Appleton Electric Co., Cooper/Crouse-Hinds, or approved equal with zinc electroplate steel or cast iron cover.
 - 2. For Wet Locations: Cast iron boxes by Cooper/Crouse-Hinds' (hot dipped galvanized or Corro-free epoxy powder coat), or OZ/Gedney Co. (hot dipped galvanized), or approved equal, with stainless steel cover screws and cast iron cover gasketed to suit application.
 - 3. For classified spaces, provide junction and pull boxes rated for Class I, Div. 1, group D hazardous areas as manufactured by Crouse-Hinds, Appleton or approved equal.
- D. Conduit Bodies, Threaded (Provided with a Volume Marking):
 - 1. For Dry, Damp Location: Zinc electroplate malleable iron or cast iron alloy bodies with zinc electroplate steel covers; Appleton Electric Co.'s Unilets, Cooper/Crouse-Hinds' Condulets, or approved equal.
 - 2. For Wet Locations: Malleable iron or cast iron alloy bodies with hot dipped galvanized or other specified corrosion resistant finish; Cooper/Crouse-Hinds' Condulets (hot dipped galvanized or Corro-free epoxy power coat), or OZ/Gedney Co.'s Conduit Bodies (hot dipped galvanized) or approved equal, with stainless steel cover screws and malleable iron covers gasketed to suit application.
 - 3. For classified spaces, provide outlet conduit bodies rated for Class I, Div. 1, group D hazardous areas as manufactured by Crouse-Hinds, Appleton, or approved equal.

2.04 SPECIFIC PURPOSE OUTLET BOXES

- A. As fabricated by manufacturers for mounting their equipment.

PART 3 - EXECUTION**3.01 PREPARATION**

- A. Before proceeding with the installation of junction and pull boxes, check the locations with the Director's Representative and have same approved.

3.02 INSTALLATION

- A. Mounting Position of Wall Outlets For Wiring Devices: Unless otherwise indicated, install boxes so that the long axis of each wiring device will be vertical.
- B. Height of Wall Outlets: Unless otherwise indicated, locate outlet boxes with their center lines at the following elevations above finished floor:

Switches	4'-0"
Single & Duplex Receptacles	1'-6"
Special Purpose Receptacles	4'-0"
Telephone/Data Outlets	1'-6"
Telephone Outlets (Wall Phones)	4'-0"
Above-Counter Devices	8" Above Counter
Fire Alarm Manual Station	4'-0"
Fire Alarm Notification Device	7'-0"

- C. Wall Outlet Location: Locations shown on drawings are approximate only. Locate wall outlet boxes as near to position indicated as possible, but so as to avoid conflicts with other trades (architectural, mechanical, plumbing, structural, etc.).
- D. Where devices of different mounting heights are shown on drawings at same location, align outlet boxes along a common vertical line.
- E. Outlet boxes in a common wall serving separate rooms shall not be installed back-to-back.
- F. Outlet boxes shall be sized to accommodate the device that is to be installed.
- G. Provide box extensions and/or trim rings as required to accommodate construction of wall/ceiling in which boxes are recessed.
- H. Supplementary Junction and Pull Boxes: In addition to junction and pull boxes indicated on the drawings and required by NFPA 70, provide supplementary junction and pull boxes as follows:
1. When required to facilitate installation of wiring.
 2. At every third 90 degree turn in conjunction with raceway sizes over 1 inch.
 3. At intervals not exceeding 100 feet in conjunction with raceway sizes over 1 inch.
- I. All Junction and Pull Boxes shall have a screw-on cover plate. Cover plate shall match box material and construction.

- J. Junction and Pull Boxes shall be installed in locations that are readily accessible, and shall not be blocked by equipment, piping, ducts, structural supports, etc.

3.03 OUTLET, JUNCTION, AND PULL BOX SCHEDULE

A. Boxes For Concealed Conduit System:

1. Non-Fire Rated Construction:
 - a. Depth: To suit job conditions and comply with NFPA 70 Article 370.
 - b. For Lighting Fixtures: Use galvanized steel outlet boxes designed for the purpose.
 - 1) For Fixtures Weighing 50 lbs. or Less: Box marked "FOR FIXTURE SUPPORT".
 - 2) For Fixtures More Than 50 lbs: Box listed and marked with the weight of the fixture to be supported (or support fixture independent of the box).
 - c. For Ceiling Suspended Fans:
 - 1) For Fans Weighing 35 lbs or Less: Marked "Acceptable for Fan Support."
 - 2) For Fans Weighing More Than 35 lbs, up to 70 lbs: Marked "Acceptable for Fan Support up to 70 lbs (or support fan independent of the box)."
 - d. For Junction and Pull Boxes: Use galvanized steel boxes with flush covers.
 - e. For Switches, Receptacles, Etc:
 - 1) Plaster or Cast-In-Place Concrete Walls: Use 4 inch or 4-11/16 inch galvanized steel boxes with device covers.
 - 2) Walls Other Than Plaster or Cast-In-Place Concrete: Use type of galvanized steel box which will allow wall plate to cover the opening made for the installation of the box.

B. Boxes For Exposed Conduit System:

1. Dry and Damp Locations: Use zinc electroplate or hot dipped galvanized threaded type malleable iron or cast iron alloy outlet, junction, and pullboxes or conduit bodies provided with a volume marking in conjunction with ferrous raceways unless otherwise specified or indicated on the drawings.
 - a. Galvanized steel boxes may be used in conjunction with conduit sizes over 1 inch in non-hazardous dry and damp locations.
 - b. Galvanized steel boxes may be used in conjunction with electrical metallic tubing where it is allowed (specified) to be installed exposed as branch circuit conduits at elevations over 10'-0" above finished floor.
2. Wet Locations: Use threaded type malleable iron or cast iron alloy outlet junction, and pullboxes or conduit bodies (provided with a volume marking) with hot dipped galvanized or other specified corrosion resistant coating in conjunction with ferrous raceways unless otherwise specified or indicated on the drawings.
 - a. Use corrosion resistant boxes in conjunction with plastic coated rigid ferrous metal conduit.

- C. Specific Purpose Outlet Boxes: Use to mount equipment when available and suitable for job conditions. Unless otherwise specified, use threaded type boxes with finish as specified for exposed conduit system, steel (painted) for surface metal raceway system and galvanized steel for recessed installations.

3.04 LABELING

- A. Identify junction and pull boxes for system served (i.e. power, lighting, fire alarm, telephone, data, public address, nurse call, etc.), using stencil lettering on box cover.
- B. Identify panelboard and circuit number of all conductors contained within junction and pull boxes, using stencil lettering on box cover.

END OF SECTION

SECTION 26 05 43 UNDERGROUND ELECTRICAL WORK

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Underground Electrical Work, as shown on the Plans, as specified, and/or directed.

1.02 REFERENCES

- A. The publications listed below and their latest revisions form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only.
1. Federal Specification (Fed. Spec.):
 - a. RR-F-621C - Frame, Covers, Gratings, Steps, Sump and Catch Basin, Manhole
 2. American Association of State Highway and Transportation Officials (AASHTO) Publications:
 - a. HB-12 - Highway Bridges, Including Interim Specifications
 - b. M 198 - Joints for Circular Concrete Sewer and Culvert Pipe Using Flexible Watertight Gaskets
 3. American Concrete Institute (ACI) Publications:
 - a. 315 - Details and Detailing of Concrete Reinforcement
 - b. 318 - Building Code Requirements for Reinforced Concrete
 4. American National Standards Institute (ANSI) Publication:
 5. C2 - National Electrical Safety Code (NESC)
 6. American Society for Testing and Materials (ASTM) Publications:
 - a. B1 - Hard-Drawn Copper Wire
 - b. B8 - Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
 - c. C32 - Sewer and Manhole Brick (Made from Clay or Shale)
 - d. C260 - Air-Entraining Admixtures for Concrete
 - e. C309 - Liquid Membrane-Forming Compounds for Curing Concrete
 - f. D698 - Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (305-mm) Drop
 - g. D1556 - Density of Soil in Place by the Sand-Cone Method
 - h. D1557 - Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop
 - i. D1682 - Breaking Load and Elongation of Textile Fabrics
 7. Association of Edison Illuminating Companies (AEIC) Publications:
 - a. Impregnated-Paper-Insulated Lead Covered Cable, Solid Type (10th Edition)
 8. National Electrical Manufacturer's Association (NEMA) Publications:

- a. RN 1 - Polyvinyl-Chloride Externally Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing
- b. TC 2 - Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
- c. TC 3 - PVC Fittings for Use With Rigid PVC Conduit and Tubing
- d. TC 6 - PVC and ABS Plastic Utilities Duct for Underground Installation
- e. TC 9 - Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation
- f. WC 7 - Cross-Linked-Thermosetting- Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-66-524)
- g. WC 8 - Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-68-516)
- 9. National Fire Protection Association (NFPA) Publication:
 - a. 70 - National Electrical Code (NEC)
- 10. U.S. Department of Agriculture, Rural Electrification Administration (REA) Bulletins:
 - a. 344-2 - List of Materials Acceptable for Use on Telephone Systems of REA Borrowers
 - b. 345-6 - Splicing Plastic-Insulated Cables (PC-2)
 - c. 345-14 - Direct Burial Telephone Cable (Air Core) (PE-23)
 - d. 345-26 - Buried Plant Housings (PE-35)
 - e. 345-67 - Filled Telephone Cables (PE-39)
- 11. Underwriters Laboratories Inc. (UL) Publications:
 - a. 6 - Rigid Metal Conduit
 - b. 467 - Grounding and Bonding Equipment
 - c. 510 - Insulating Tape
 - d. 514A - Metallic Outlet Boxes
 - e. 514B - Fittings for Conduit and Outlet Boxes
 - f. 854 - Service-Entrance Cables
 - g. 1242-83 - Intermediate Metal Conduit

1.03 GENERAL REQUIREMENTS

- A. The following Sections apply to this Section with additions and modifications specified herein:
 - 1. Section 26 05 01, "Electrical General Requirements"
 - 2. Section 26 05 26 "Grounding".
 - 3. Section 26 05 34 "Conduit".
 - 4. Section 26 05 19 "Wiring/Cable, 600Volts and Under".
- B. Laboratory Tests:
 - 1. Determine soil-density relationships for compaction of backfill material in accordance with ASTM D1557, Method D.

1.04 SUBMITTALS

- A. Shop Drawings including Manufacturer's Data:

1. Conduit spacers for encased concrete duct bank buried detectable warning tape
 2. Bedding material
 3. Backfill material
 4. Concrete
 5. Rebar and reinforcing materials
 6. Splice box
 7. Insulating tape
 8. Handhole frame and cover
- B. Manufacturer's Instructions:
1. Manufacturer's directions for use of ground megger with proposed method indicated
 2. Terminator manufacturer's installation instructions

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. Provide materials and equipment listed by UL or approved by Factory Mutual (FM) System when such equipment is listed or approved.
- B. Conduit: Shall be per Section 26 05 34 "Conduit".
- C. Plastic Insulating Tape: UL 510.
- D. Wire and Cable Shall be per Section 26 05 19 "Wiring/Cable, 600Volts and Under"
1. Connectors and Terminals: Shall be designed and approved for use with the associated conductor material, and shall provide a uniform compression over the entire contact surface. Solderless terminal lugs shall be used on stranded conductors. For connecting aluminum to copper, connectors shall be the circumferentially compressed, metallurgically bonded type.
- E. Grounding and Bonding Equipment: Per Section 26 05 26 "Grounding".
- F. Materials for Manholes and Hand Holes: Referred to throughout this Section as "structures" or "underground structure".
1. Polymer Concrete Hand Holes: Shall be matched die molded of dark green fiberglass. When buried, the unit shall be weight load rated as Tier T22: 22,000 pound design and 33,750 pound test (ANSI). Unit shall have precut 6-inch by 6-inch cable entrance at the center bottom of each side. A weatherproof cover with nonskid surface shall be provided for each hand hole. Covers shall be capable of being locked into position.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Underground installation shall conform to ANSI C2 and NFPA 70 except as otherwise specified or indicated.
- B. Contractor Damage: The Contractor shall promptly repair any indicated utility lines or systems damaged by Contractor operations. If the Contractor is advised in writing of the location of a non-indicated line or system, such notice shall provide that portion of the line or system with "indicated" status in conformance with the Contract Documents. The Contractor shall immediately notify the Engineer of any such damage to any underground line that is indicated on Contract Drawings, indicated by supplemental information from the Engineer or not indicated.
- C. Underground Duct Without Concrete Encasement: Direct buried ductbank systems. Shall be as shown on the Contract Documents.
 - 1. The top of the conduit shall be not less than 24 inches below grade, shall have a minimum slope of 3 inches in each 100 feet away from buildings and toward manholes and other necessary drainage points, and shall run in straight lines except where a change of direction is necessary. As each conduit run is completed, a testing mandrel not less than 12 inches long with a diameter 1/4 inch less than the inside diameter of the conduit shall be drawn through each conduit, after which a stiff-bristled brush shall be drawn through until the conduit is clear of earth, sand, or gravel particles. Conduit plugs shall then immediately be installed. Ensure a minimum 3-inch clearance from the conduit to each side of the trench. Grade the bottom of the trenches smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 3 inches; fill with sand or earth, free from particles that would be retained on a 1/4-inch sieve; and tamp level with the original bottom.
 - 2. Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 3-inch concrete cover around ducts. The concrete encasement shall extend at least 8 feet beyond the edges of paved areas and roads, and 12 feet beyond the rails on each side of railroad tracks. Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, shall be zinc-coated, rigid steel, jacked into place. Hydraulic jet method shall not be used.
 - 3. Separate multiple conduits with a minimum concrete thickness of 2 inches, except that light and power conduits shall be separated from control, signal, and telephone conduits by a minimum distance of 12 inches. Stagger the joints of the conduits by rows and layers to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly shall consist of base spacers, intermediate spacers, and top spacers to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

- D. Underground Duct With Concrete Encasement: Encased only and reinforced concrete duct banks. Shall be constructed of individual conduits encased in concrete. Except where rigid galvanized steel conduit is indicated or specified, the conduit shall conform to NEMA TC 6, Type EB. The type of conduit used shall not be mixed in any one duct bank. Ducts shall be a minimum of 4 inches in diameter unless otherwise indicated. The concrete encasement surrounding the bank shall be rectangular in cross-section and shall provide at least 3 inches of concrete cover around ducts. Separate conduit by a minimum concrete thickness of 2 inches, except separate light and power conduits from control, signal, and telephone conduits by a minimum concrete thickness of 12 inches.
1. The top of the concrete envelope shall be a minimum of 18 inches below grade, except under roads and pavement, concrete envelope shall be a minimum of 24 inches below grade. Duct banks shall have a continuous slope downward toward underground structures and away from buildings with a minimum pitch of 3 inches in 100 feet. Except at conduit risers, changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 25 feet; sweep bends may be composed of one or more curved or straight sections or combinations thereof. Manufactured bends shall have a minimum radius of 18 inches for use with conduits of less than 3 inches in diameter and a minimum radius of 36 inches for ducts of 3 inches in diameter and larger. Excavate trenches along straight lines from structure to structure before ducts are laid or structure constructed so the elevation can be adjusted, if necessary, to avoid unseen obstruction.
 2. Terminate conduits in end-bells where ducts enter underground structures. Stagger the joints of the conduits by rows and layers to strengthen the duct bank. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly shall consist of base spacers, intermediate spacers, and top spacers to provide a completely enclosed and locked-in duct bank. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of duct bank. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring shall be done by driving reinforcing rods adjacent to every other duct spacer assembly and attaching the rod to the spacer assembly.
 3. As each section of a duct bank is completed from structure to structure, a testing mandrel not less than 12 inches long with a diameter 1/4 inch less than the inside diameter of the conduit shall be drawn through each conduit, after which a stiff-bristled brush, having the diameter of the conduit shall be drawn through until the conduit is clear of earth, sand, and gravel particles. Conduit plugs shall then be immediately installed.
 4. New conduit indicated as being unused or empty shall be provided with plugs on each end. Plugs shall contain a weep hole or screen to allow water drainage. Provide a plastic pull rope (minimum 200# rating) having 3 feet of slack at each end of unused or empty conduits.
 5. Connections to Manholes/Handholes: Duct bank envelopes connecting to underground structures shall be flared to have an enlarged cross-section at the manhole entrance to provide additional shear strength. The dimensions of the flared cross-section shall be larger than

the corresponding manhole opening dimensions by no less than 12 inches in each direction. The perimeter of the duct bank opening in the underground structure shall be flared toward the inside or keyed to provide for a positive interlock between the duct bank and the wall of the structure. Vibrators shall be used when this portion of the envelope is poured to assure a seal between the envelope and the wall of the structure.

- a. For connection to precast concrete and cast-in-place concrete handholes/manholes: Provide concrete encasement for all conduit ductbank systems (direct buried conduit ductbank, concrete encased conduit ductbank, reinforced concrete encased ductbank) connections at handholes a minimum of 48" from manhole/handhole. Concrete shall be keyed into manhole/handhole.
 6. Connections to Concrete Pads: For duct bank connections to concrete pads, break an opening in the pad out to the dimensions required and preserve the steel in the pad. Cut the steel and extend it into the duct bank envelope. Chip out the opening in the pad to form a key for the duct bank envelope.
 7. Connections to Existing Ducts: Where connections to existing duct banks are indicated, excavate the banks to the maximum depth necessary. The banks shall be cut off and loose concrete removed from the conduits before new concrete-encased ducts are installed. A reinforced concrete collar, poured monolithically with the new duct bank, shall be provided to take the shear at the joint of the duct banks. Remove existing cables which constitute interference with the work. Abandon in place the unused ducts and cables which do not interfere with the work.
 8. Partially Completed Duct Banks: During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud, sand, and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 2 feet back into the envelope and a minimum of 2 feet beyond the end of the envelope. Provide one No. 4 bar in each corner, 3 inches from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 1 foot apart. Restrain reinforcing assembly from moving during concrete pouring.
- E. Concrete for Electrical Requirements: Shall be composed of fine and coarse aggregate, Portland cement, and water proportioned and mixed to produce a plastic, workable mixture. Fine aggregate shall be of hard, dense, durable, clean, and uncoated sand. The coarse aggregate shall be 3/16 inch to 1 inch size. The fine and coarse aggregates shall not contain dirt, vegetable matter, soft fragments, or other deleterious substances. Water shall be fresh, clean, and free from salts, alkali, organic matter, and other impurities. Concrete shall be 4,000 psi minimum ultimate 28-day compressive strength. Slump shall not exceed 4 inches. Retempering of concrete will not be permitted. Exposed, unformed concrete surfaces shall be given a smooth, wood float finish. Concrete shall be cured for a period of not less than 7 days, and concrete made with high early strength Portland cement shall be repaired by patching honeycombed or otherwise defective areas with cement mortar as directed. Air entrain concrete

exposed to weather using an air-entraining admixture conforming to ASTM C260. Air content shall be between 4 and 6 percent.

- F. Buried Utility Warning and Identification Tape: Provide detectable aluminum foil plastic-backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried cable and conduit. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 2 inches minimum width, color coded for the utility involved with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be CAUTION BURIED ELECTRIC or TELEPHONE CABLE BELOW or similar. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material. Bury tape with the printed side up at a depth of 12 inches below the top surface of earth or the top surface of the subgrade under pavements.
- G. Reconditioning of Surfaces:
1. Unpaved surfaces disturbed during the installation of duct or direct burial cable shall be restored to the original elevation and condition. Sod or topsoil shall be preserved carefully and replaced after the backfilling is completed. Replace damaged sod with sod of equal quality. Where the surface is disturbed in a newly seeded area, the disturbed surface shall be reseeded with the same quantity and formula of seed as that used in the original seeding.
 2. Paving Repairs: Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists, such surface treatment or pavement shall be restored to the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces in a neat and acceptable manner.
- H. Cable Pulling: Test existing ducts with a mandrel and thoroughly swab out to remove foreign material before the pulling of cables. Cables shall be pulled down grade with the feed-in point at the manhole or buildings of the highest elevation. Flexible cable feeds shall be used to convey cables through the manhole opening and into the ducts. Cable lubricants shall be lubricants specifically recommended by the cable manufacturer. Cable-pulling tensions shall not exceed the maximum pulling tension recommended by the cable manufacturer. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape shield shall have a bending radius not less than 12 times the overall diameter of the completed cable. Cable with wire shield shall have a bending radius not less than eight times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.
1. Installation of Cables in Manholes, Hand Holes, and Vaults: Route cables along walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls without interference to duct entrances. Support cables on brackets and cable insulators at a maximum of 4 feet. In existing manholes, hand holes, and vaults where new ducts are to be terminated, or where new cables are to be installed,

the existing installation of cables, cable supports, and grounding shall be modified as required with cables arranged and supported as specified for new cables. Identify each cable by corrosion-resistant embossed metal tags attached in each underground structure in accordance with the cable schedule and as approved by the Engineer. Example: 600V cable, Circuit 4-Sub. NB - to SP. Identify each phase of the 600V cable.

- I. Hand Holes:
 - 1. Precast Hand Holes Installation: Commercial precast assembly shall be set on 6 inches of level, 90 percent compacted granular fill, 3/4 inch to 1 inch size, extending minimally 12 inches beyond the hand hole on each side. Granular fill shall be compacted by a minimum of four passes with a plate type vibrator. Installation shall conform to the manufacturer's instructions.

- J. Excavating, Backfilling, and Compacting: Excavate underground structures to depths indicated. If hard material is encountered, the provisions of the Contract respecting an adjustment for changed conditions shall apply, subject to the requirements of notification thereunder being given. Hard material shall be defined as solid rock; firmly cemented unstratified masses; conglomerate deposits possessing the characteristics of solid rock not ordinarily removed without systematic drilling and blasting; or any boulder, masonry, or concrete (except pavement) exceeding 1/2 cubic yard in volume.
 - 1. Excavated materials not required or suitable for backfill shall be removed from the project site. Provide sheeting and shoring as necessary for protection of work and safety of personnel. Remove water from excavation by pumping or other approved method.
 - 2. Backfilling around structures shall consist of earth, loam, sand-clay, or sand and gravel, free from large clods of earth or stones over 1 inch in size. Backfill materials shall be placed symmetrically on all sides in loose layers not more than 9 inches deep. Each layer shall be moistened, if necessary, and compacted with mechanical or hand tampers to 90 percent compaction.
 - 3. Backfilling Trenches: Place backfill in layers not more than 6 inches thick, and compact each layer. Backfilling shall progress as rapidly as the construction, testing, and acceptance of the work permits. Backfill shall be free from roots, wood scrap material, and other vegetable matter and refuse. Compaction of backfill shall be to 90 percent of ASTM D698 density. The first layer shall be earth or sand, free from particles that would be retained on a 1/4-inch sieve and extending not less than 3 inches above the top of the conduit or cables. The succeeding layers shall be excavated material having stones no larger than would pass through a 4-inch ring. The backfill may be moistened. The backfill shall be level with the adjacent surface, except that in sodded areas, leave a space equal to the thickness of the sod.

- K. Cable Terminating: Protect terminations of insulated power and lighting cables from accidental contact, deterioration of coverings, and moisture by the use of terminating devices and materials. Make terminations by using materials and methods indicated or specified herein or as designated by the written instruction of the cable manufacturer and termination kit manufacturer. Adequately support

cables and cable terminations to avoid any excessive strain on the termination and the conductor connection.

- L. Splices for 600-Volt Class Cables: Splices in underground conduit systems shall be made only in accessible locations such as manholes and hand holes, using a compression connector on the conductor and by insulating and waterproofing by one of the following methods suitable for continuous submersion in water.
 - 1. Cast-type splice insulation shall be provided by means of a molded casting process employing a thermosetting epoxy resin insulating material which shall be applied by a gravity-poured method or by a pressure-injected method. The component materials of the resin insulation shall be in a packaged form ready for convenient mixing without removing from the package. Do not allow the cables to be moved until after the splicing material has completely set.
 - 2. Gravity-poured method shall employ materials and equipment contained in an approved commercial splicing kit which includes a mold suitable for the cables to be spliced. When the mold is in place around the joined conductors, prepare and pour the resin mix into the mold. Do not allow cables to be moved until after the splicing materials have completely set.
- M. Grounding: Shall be per Section 26 05 26 "Grounding".
- N. Special Conditions: During the construction of duct banks and underground structures located in access roads, streets and similar traffic areas, these area shall remain open to traffic. Plan and execute the work to meet this condition. At locations where duct banks cross railroad tracks and the work requires closing of the tracks, secure permission from the Engineer and Railroad Owner for each track closure.

3.02 FIELD TESTS

- A. As an exception to requirements that may be stated elsewhere in the Contract, notify the Engineer in writing at least 5 working days prior to each test. Furnish labor, equipment, and incidentals required for testing, except that the Owner will provide electric power required for the tests. Correct defects in the work provided by the Contractor and repeat tests until the work is in compliance with contract requirements. Show by demonstration in service that circuits and devices are in good operating condition. Tests shall be such that each item of control equipment will function not less than five times.
- B. Compaction: Backfill shall be tested in accordance with ASTM D1556, one test per lift per 2000 square feet.

END OF SECTION

SECTION 26 24 16 PANELBOARDS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Under this Section, the Contractor shall furnish all labor, materials, equipment and accessories for Panelboards, as shown on the Plans, as specified and/or directed.

1.02 REFERENCES

- A. The publications listed below and their latest revisions form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only and shall be the most current version.
 - 1. National Electrical Contractors Association (NECA) Publication:
 - 2. Standard of Installation
 - 3. National Electrical Manufacturers Association (NEMA) Publications:
 - a. AB1 - Molded Case Circuit Breakers
 - b. PB 1 - Panelboards
 - c. PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less
 - 4. National Fire Protection Association (NFPA) Publication:
 - a. 70 - National Electrical Code

1.03 SUBMITTALS

- A. Submittal Packages: Submit the shop drawings, product data, and the quality control submittals specified below at the same time as a package.
- B. Shop Drawings: Include the following for each panelboard.
 - 1. Cabinet and gutter size.
 - 2. Voltage and current rating.
 - 3. Panelboard short circuit rating. Indicate if rating is Fully Rated Equipment Rating, or where acceptable, UL listed Integrated Equipment Short Circuit Rating.
 - 4. Circuit Breaker Enumeration (Frame, Poles, KAIC.): Indicate if circuit breakers are suitable for the panelboards' Fully Rated Equipment Rating, or where acceptable, are series connected devices that have been test verified and listed with UL (include documentation proving the compatibility of the proposed circuit breaker combinations). Circuit breakers do not have to be listed as series connected devices when all of the circuit breaker interrupting ratings are equal to, or greater than, the short circuit rating of the panelboard.
 - 5. Accessories.

- C. Product Data:
 - 1. Catalog sheets, specifications and installation instructions.
 - 2. Bill of materials.
- D. Maintenance Data: Include spare parts listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.
- E. Contract Closeout Submittals:
 - 1. Operation and Maintenance Data: Deliver 2 copies, covering the installed products, to Owner.

PART 2 - PRODUCTS

2.01 PANELBOARDS

- A. As produced by Cutler-Hammer/Eaton Corp, General Electric Co., , or Square D Co., having:
 - 1. Surface type.
 - 2. Increased gutter space for gutter taps, sub-feed wiring, through-feed wiring, oversize lugs.
 - 3. UL label "SUITABLE FOR USE AS SERVICE EQUIPMENT" where used as service equipment.
 - a. Where indicated, equip panelboards used as service equipment with secondary surge arresters; GE's Tranquell Series, Joslyn's Mfr. Co.'s Surge Tec Series, Intermatic Incorp.'s AG2401 or AG6503, Square D Co.'s SDSA 1175 or SDSA 3650, to suit system primary (transformer size, available current) and secondary characteristics.
 - 4. Door and one piece trim. Door fastened to trim with butt or piano hinges. Trim fastened to cabinet with devices having provision for trim adjustment. Provide door-in-door trim.
 - 5. Door lock. 2 keys with each lock. All locks shall be keyed alike.
 - 6. Solid copper bus bars. Ampere rating of bus bars not less than frame size of main circuit breaker.
 - 7. Full capacity copper isolated neutral bus in panelboards where neutrals are required and the panel is not utilized as service equipment.
 - 8. Copper equipment grounding bus in panelboards where equipment grounding conductors are required.
 - 9. Sections designated "space" or "provision for future breaker" equipped to accept future circuit breakers.
 - 10. Lock on devices for exit light, fire alarm, stair well circuits or as indicated on Contract Drawings.
 - 11. Provisions for padlocking circuit breaker handle in OFF position where indicated.
 - 12. Blank circuit directories in plastic pockets.

13. Short circuit rating not less than indicated on panelboard schedule. Furnish panelboards having Fully Rated Equipment Rating (the short circuit rating of the panelboard is equal to the lowest interrupting rating of any device installed in the panelboard).
14. Molded Case Circuit Breakers.
 - a. Molded Case Circuit Breakers: NEMA AB 1, bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles. Do not use tandem circuit breakers. Type HACR for air conditioning equipment circuits, Class A ground fault interrupter circuit breakers where scheduled. The fault interrupter shall detect and trip on current imbalance of 6 milliamperes or greater per requirements of UL 943 for Class A GFCI devices.
 - b. Components: See panelboard schedule for specific components required for each circuit breaker. In addition to the specific components, equip each circuit breaker with additional components as required to achieve a coordinated selective scheme between the main circuit breaker and the branch/feeder circuit breakers when indicated on the panelboard schedule that a coordinated selective scheme is required.
 - c. Single pole 15 amp and 20 amp circuit breakers marked SWD where used as switches.
 - d. Single pole and two pole 15, 20, and 30 amp circuit breakers rated for high intensity discharge lighting loads when applicable.
15. Size of circuit breakers and rating of main lugs shall be as indicated on Contract Drawings.
16. Enclosure: NEMA 1.

2.02 NAMEPLATES

- A. General: Precision engrave letters and numbers with uniform margins, character size minimum 3/16 inch high.
 1. Phenolic: Two color laminated engravers stock, 1/16 inch minimum thickness, machine engraved to expose inner core color (white).
 2. Aluminum: Standard aluminum alloy plate stock, minimum .032 inches thick, engraved areas enamel filled or background enameled with natural aluminum engraved characters.
 3. Materials for Outdoor Applications: As recommended by nameplate manufacturer to suit environmental conditions.
 4. Provide the following information on the panelboard door:
 - a. Panel designation
 - b. "Fed from". Descriptive location and/or main feeder connection indication.
 - c. Volts
 - d. 1 or 3 Phase indication and wire indication
 - e. Bus Amperage
 - f. Feeder phase/wire color designations.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install panelboards in accordance with NEMA Publication No. PB1.1 "General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less".
- B. Flush Cabinets: Set flush cabinets so that edges will be flush with the finished wall line. Where space will not permit flush type cabinets to be set entirely in the wall, set cabinet as nearly flush as possible, and cover the protruding sides with the trim extending over the exposed sides of the cabinet and back to the finished wall line.
- C. Directory: Indicate on typewritten directory the equipment controlled by each circuit breaker, and size of feeder servicing panelboard. For power panelboards also include ATE rating and feeder size for each breaker.
- D. Identification:
 - 1. Install nameplates on front of each panelboard.
 - a. Identification of 120/208 Volt Circuit Conductors:
 - 1) 2 wire circuit - white*, black.
 - 2) 3 wire circuit - white*, black, red.
 - 3) 4 wire circuit - white*, black, red, blue.*White is used only as neutral. Where neutral is not required, black, red, or black, red, blue is used for phase to phase circuits.
 - b. Identification of 277/480 Volt Circuit Conductors:
 - 1) 2 wire circuit - natural gray**, brown.
 - 2) 3 wire circuit - natural gray**, brown, yellow.
 - 3) 4 wire circuit - natural gray**, brown, yellow, orange.**Natural gray is used only as neutral. Where neutral is not required, brown, yellow, or brown, yellow, orange is used for phase to phase circuits.
- E. Height: 6 feet to top of panelboard; install panelboards taller than 6 feet with bottom no more than 4 inches above floor.
- F. Provide filler plates for unused spaces in panelboards.
- G. Provide typed circuit directory for each branch circuit panelboard. Revise directory to reflect circuiting changes required to balance phase loads.

3.02 FIELD QUALITY CONTROL

- A. System Acceptance Test:
 - 1. Preparation: Notify Owner/Engineer at least 3 working days prior to the test so arrangements can be made prior to the test to have a Facility Representative witness the test.
 - 2. Make the following tests:

- a. Test circuit breakers that have ground fault protection.
- b. Test programmable solid state trip devices in accordance with the manufacturer's recommendations.
- c. Supply all equipment necessary for system adjustment and testing.
- d. Measure steady state load currents at each panelboard feeder; rearrange circuits in the panelboard to balance the phase loads to within 20percent of each other. Maintain proper phasing for multi-wire branch circuits.

END OF SECTION

SECTION 26 27 26 WIRING DEVICES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Wiring Devices as shown on the Plans, as specified, and/or directed.

1.02 REFERENCES

- A. NEMA
- B. UL
- C. NFPA 70

1.03 SUBMITTALS

- A. Product Data: Catalog sheets, specifications and installation instructions.

1.04 RELATED SECTIONS

- A. Section 26 05 01, "Electrical General Requirements", applies to this Section, with the additions and modifications specified herein.

PART 2 - PRODUCTS

2.01 SWITCHES

- A. Local Switches, Single Pole: 20A, 120/277 V ac; Bryant's 4901, Crouse-Hinds/AH's 1991, Hubbell's 1121/1221, Leviton's 1121/1221, Pass & Seymour's 20AC1.
- B. Local Switches, Double Pole: 20A, 120/277 V ac; Bryant's 4902, Crouse-Hinds/AH's 1992, Hubbell's 1222/1122, Leviton's 1222/1122, Pass & Seymour's 20AC2.
- C. Local Switches, Three-Way: 20A, 120/277 V ac; Bryant's 4903, Crouse-Hinds/AH's 1993, Hubbell's 1223/1123, Leviton's 1223-2/1123-2, Pass & Seymour's 20AC3.
- D. Local Switches, Four-Way: 20A, 120/277 V ac; Bryant's 4904, Crouse-Hinds/AH's 1994, Hubbell's 1224/1124, Leviton's 1224-2/1124-2, Pass & Seymour's 20AC4.
- E. Local Switches, Dimming: 20A, 120/277 V ac; Eaton's WBSD-010SLD, Leviton's 66EV-10W, Pass & Seymour's WS4FBL3PW.

2.02 RECEPTACLES

- A. Federal Spec./NEMA Grade Receptacles:
 - 1. Single receptacle, NEMA 5-20R (20A, 125 V, 2P, 3W); Bryant's 5361, Crouse-Hinds/AH's 5361, Hubbell's 5361, Leviton's 5361, or Pass & Seymour's 5361.
 - 2. Duplex receptacle, NEMA 5-20R (20A, 125 V, 2P, 3W); Bryant's 5362, Crouse-Hinds/AH's 5739-S, Hubbell's 5362, Leviton's 5362, Pass & Seymour's 5362, or Daniel Woodhead's 5362 DW.
- B. Ground Fault Interrupter Receptacles: Duplex receptacle rated 20A (NEMA 5-20R), circuit ampacity 20A; Bryant's GFR53FT, Crouse-Hind/AH's GF5342, Hubbell's GF 5352, Leviton's 6899, Pass & Seymour's 2091S,

2.03 WALL PLATES

- A. Stainless Steel Wall Plates: Type 302 stainless steel with satin finish. All areas except finished spaces or wet locations.
- B. Weatherproof/Wet Location Covers: UL 514D type "extra duty". Thomas & Betts Red Dot Code Keeper type 2CKU or equal.
- C. Finished areas: Polycarbonate. Color to match device color.

2.04 NAMEPLATES

- A. Phenolic Type: Standard phenolic nameplates with 3/16 inch minimum size lettering engraved thereon.
- B. Embossed Aluminum: Standard stamped or embossed aluminum tags, 3/16 inch minimum size lettering, as produced by Seton Name Plate Corp. or Tech Products Inc.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install wiring devices in outlet boxes.
- B. Local Switches:
 - 1. Install local switches rated 20A, 120/277 V ac for switches unless otherwise shown on the drawings or specified.
 - 2. Where more than one switch occurs at same location in a 120 volt system, arrange switches in gangs and cover with one face plate.
 - 3. Install single and double pole switches so that switch handle is up when switch is in the "On" position.
- C. Receptacles:

1. Install Specification Grade receptacles, NEMA 5-20R, 20A, 125 V, 2P, 3W, for duplex receptacles and single receptacles unless otherwise shown on the drawings or specified.
 2. Install receptacles with ground pole in the down position.
- D. Wall Plates:
1. Install wall plates on all wiring devices in dry locations, with finish to match hardware in each area.
- E. Weatherproof In-use Covers: Install weatherproof covers on wiring devices in damp and wet locations.
- F. Nameplates: Provide phenolic or embossed aluminum nameplate for each special purpose receptacle indicating phase, ampere and voltage rating of the circuit. Attach nameplate with rivets or tamperproof fasteners to wall plate or to wall above receptacle. Wall plates may be engraved with required data in lieu of separate nameplates.
- G. Labels: Provide electronically-generated, self-sticking label at each wiring device. Label shall indicate panel designation and circuit number associated with respective device. Label shall be attached to outside of wall plate.
- H. Where Contract Drawings call out a classified area all equipment/devices and wiring methods to be suitable for this area per NEC. Refer to Contract Drawings for classified area locations.

END OF SECTION

SECTION 26 28 14

CIRCUIT BREAKERS FOR EXISTING PANELBOARDS

PART 1 - GENERAL

1.01 DESCRIPTION:

- A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Circuit Breakers For Existing Panelboards, as shown on the Plans, as specified and/or directed.

1.02 SUBMITTALS:

- A. Not Required.

PART 2 - PRODUCTS

2.01 CIRCUIT BREAKERS

- A. Similar to existing circuit breakers.
- B. Compatible with existing panelboard.
- C. Number of poles and ampere trip rating as indicated on Contract Drawings.
- D. Complete with accessories required for installation.
- E. All heating and air conditioning circuit breakers shall be "HACR" rated.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install new circuit breakers in existing panelboards where indicated.
- B. Add new circuits equally across phases to prevent overloading any phase in the panelboard. After new and existing circuits are energized, take current reading on panelboard feeder during a heavy usage time period. If phases are substantially unbalanced, rearrange both new and existing circuits in panelboard to equally distribute load between all phases, and provide new typewritten directory indicating equipment controlled by each circuit breaker.

END OF SECTION

SECTION 26 28 16 SAFETY SWITCHES

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Safety Switches as shown on the Plans, as specified, and/or directed.

1.02 SUBMITTALS

- A. Product Data: Catalog sheets, specifications and installation instructions.

PART 2 - PRODUCTS

2.01 SAFETY SWITCHES (SINGLE THROW)

- A. NEMA KS1, switches serving as motor-disconnect means shall be horsepower rated. Provide heavy-duty type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches.
- B. Fused Switches: Provide fused switch as required or indicated. Fused switches shall utilize Class R fuse holders and fuses unless otherwise indicated.
- C. Enclosure: Enclosure shall be NEMA rated for installation environment.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install switches so that the maximum height above the floor to the center of the operating handle does not exceed 6'-6".
- B. Identify each safety switch, indicating purpose or load served:
 - 1. NEMA 1 Enclosures: Rivet or bolt nameplate to the cover.
 - 2. NEMA 12 Enclosures: Rivet or bolt and gasket nameplate to the cover.
 - 3. NEMA 3R, 4, 4X Enclosures: Attach nameplate to the cover using adhesive specifically designed for the purpose, or mount nameplate on wall or other conspicuous location adjacent to switch. Do not penetrate enclosure with fasteners.

END OF SECTION

SECTION 26 51 01 INTERIOR LIGHTING

PART 1 - GENERAL

1.01 SCOPE

- A. The work under this Interior Lighting includes interior luminaires and accessories, exit signs, and building-mounted exterior lighting.

1.02 REFERENCE STANDARDS

- A. RoHS – Restriction of Hazardous Substances. Council of the European Union (EC) Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment.
- B. LM-79-08 (or latest) – IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
- C. LM-80-08 (or latest) – IES Approved Method for Measuring Lumen Maintenance of LED Light Sources.
- D. TM-21-11 (or latest) – IES Technical Memorandum on Projecting Long Term Lumen Maintenance of LED Light Sources.
- E. NEMA SSL 1-2010 (or latest) – Electronic Drivers for LED Devices, Arrays, or Systems.

1.03 SUBMITTALS

- A. Include outline drawings, lamp and ballast data, support points, weights, accessory information and performance data for each luminaire type.
- B. For each luminaire type, submit luminaire information including catalog cuts with highlighted catalog numbers and required accessories:
 - 1. Luminaire:
 - a. Manufacturer and catalog number,
 - b. Type (identification) as indicated on the plans and schedule,
 - c. Delivered lumens,
 - d. Input watts,
 - e. Efficacy,
 - f. Color rendering index.
 - 2. Driver:
 - a. Manufacturer and catalog number,
 - b. Type (Non-Dimming, Step-dimming, Continuous dimming, etc.),
 - c. Power Factor, Crest Factor, THD, etc.

1.04 OPERATION AND MAINTENANCE DATA

- A. All operations and maintenance data shall comply with the submission and content requirements specified under Section General Requirements.

1.05 EXTRA MATERIALS

- A. Provide three (3) percent of each lamp type, but not less than one (1) of each type.
- B. Provide one (1) of each type of LED module, light bar, or array (if applicable). If the LED's are integrated into the luminaire and are not separate components, provide one (1) of each of these types of luminaires.
- C. Provide one (1) LED driver or ballast of each type.

1.06 DEFINITIONS

- A. Driver: The power supply used to power LED luminaires, modules, or arrays.
- B. Rated Life: The reported life of an LED component or system to reach 70% lumen maintenance, or 70% of the LED's original light output. This test is being developed by the IES and is currently described by TM-21-11.
- C. LEDs: Broadly defined as complete luminaire with light emitting diode (LED) packages, modules, light bars or arrays, complete with driver.
- D. LED luminaire failure: Negligible light output from more than 10 percent of the LED's constitutes luminaire failure.

PART 2 - PRODUCTS

2.01 INTERIOR LUMINAIRES AND ACCESSORIES

- A. See the Luminaire Schedule on the drawings for type of luminaires and catalog numbers. Catalog numbers are shown on the drawings for quality and performance requirements only. Luminaires manufactured by others are equally acceptable provided they meet or exceed the performance of the indicated luminaires, and meet the intent of the design.
- B. Luminaire shall be listed by a NRTL (Nationally Recognized Testing Laboratory: e.g., UL, ETL, etc.).
- C. Provide luminaires with quick-connect disconnecting means, similar to Thomas & Betts Sta-Kon.
- D. Fluorescent T8 lamps and ballasts shall be listed on CEE high-performance qualifying product list and approved by Focus-On-Energy.

2.02 GENERAL USE LAMPS

- A. General Use Incandescent Lamps and Incandescent Reflector Lamps are prohibited. Use LED retrofit lamps or LED luminaires in lieu of incandescent or halogen luminaires. LED retrofit lamps shall be:
1. Rated for the voltage of the incandescent lamp/luminaire they are replacing.
 2. Dimmable where required as indicated on the Plans.
 3. Rated for the luminaire in which they are being installed. Verify whether the luminaire is enclosed and whether the LED retrofit lamp is rated for enclosed luminaires and the temperatures that will be encountered.
 4. LED lamps/luminaires shall provide delivered footcandles equal to or greater than the footcandles provided by an equivalent incandescent lamp/luminaire.
 5. LED retrofit lamps shall have an average rated life of 25,000 hours, minimum.
 6. Lamp color temperature shall be nearly equal to the incandescent lamp it is replacing.
- B. All lamps shall be new.

2.03 LED LUMINAIRES

- A. LED Luminaires shall meet all DesignLights Consortium® (DesignLights.org) Product Qualification Criteria. This does not require that the luminaire be listed on the DesignLights Consortium's® Qualified Products List, but they must meet the Product Qualification Criteria. The technical requirements that the luminaire shall meet for each Application Category are:
1. Minimum Light Output.
 2. Zonal Lumen Requirements.
 3. Minimum Luminaire Efficacy.
 4. Minimum CRI.
 5. L70 Lumen Maintenance.
 6. Minimum Luminaire Warranty of 5 years (not pro-rated) to include LED driver and all LED components.
- B. Color Temperature of 3000K-4100K for interior luminaires as listed in the Luminaire Schedule on the Plans. The color temperature of exterior LED luminaires should not exceed 4100K (nominal).
- C. Color Consistency: LED manufacturer shall use a maximum 3-step MacAdam Ellipse binning process to achieve consistent luminaire-to-luminaire color for interior luminaires. Exterior luminaires shall use a maximum 5-step MacAdam Ellipse binning process.
- D. Glare Control: Exterior luminaires shall meet DesignLights Consortium's® criteria for Zonal Lumen Distribution requirements or Backlight-Uplight-Glare (BUG) standards for exterior luminaires.
- E. Luminaire shall be mercury-free, lead-free, and RoHS compliant.

- F. Luminaire shall comply with FCC 47 CFR part 15 non-consumer RFI/EMI standards.
- G. Light output of the LED system shall be measured using the absolute photometry method following IES LM-79 and IES LM-80 requirements and guidelines.
- H. Luminaire shall maintain 70% lumen output (L70) for a minimum of 50,000 hours.
- I. Lumen output shall not depreciate more than 20% after 10,000 hours of use.
- J. Luminaire and driver shall be furnished from a single manufacturer to ensure compatibility.
- K. Luminaire Color Rendering Index (CRI) shall be a minimum of 80 for interior luminaires, and a minimum of 70 for exterior luminaires.
- L. LED luminaire shall be thermally designed as to not exceed the maximum junction temperature of the LED for the ambient temperature of the location the luminaire is to be installed. Rated case temperature shall be suitable for operation in the ambient temperatures typically found for the intended installation. Exterior luminaires to operate in ambient temperatures of -40°F to 104°F (-40°C to 40°C).
- M. Luminaire shall operate normally for input voltage fluctuations of plus or minus 10 percent.
- N. Luminaire shall have a maximum Total Harmonic Distortion (THD) of $\leq 20\%$ at full input power and across specified voltage range.
- O. All connections to luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.
- P. All luminaires shall be provided with knockouts for conduit connections.
- Q. The LED luminaire shall carry a limited 5-year warranty minimum for LED light engine(s)/board array, and driver(s).
- R. Provide all of the following data on submittals:
 - 1. Delivered lumens
 - 2. Input watts
 - 3. Efficacy
 - 4. Color rendering index.
- S. LED Luminaires used for Emergency Egress Lighting: The failure of one LED shall not affect the operation of the remaining LEDs.
- T. Emergency LED Luminaire Compatibility with Inverters shall be sine-wave type, or have written confirmation from the luminaire manufacturer that the luminaire will function with a square-wave inverter.

2.04 LED DRIVERS

A. General Drivers:

1. Provide driver type (non-dimmed, step-dimmed, continuous-dimming, etc.) as indicated on the luminaire schedule on the drawings.
2. Minimum Warranty of 5 years (not pro-rated) to include LED driver and all LED components.
3. Driver shall have a rated life of 50,000 hours, minimum.
4. Driver and LEDs shall be furnished from a single manufacturer to ensure compatibility.
5. Driver shall have a minimum power factor (pf) of 0.9 and a maximum crest factor (cf) of 1.5 at full input power and across specified voltage range.
6. Driver shall operate normally for input voltage fluctuations of plus or minus 10 percent.
7. Driver shall have a maximum Total Harmonic Distortion (THD) of $\leq 20\%$ at full input power and across specified voltage range.
8. Wiring connections to LED drivers shall utilize polarized quick-disconnects for field maintenance.
9. Fuse Protections: All luminaires shall have built-in fuse protection. All power supply outputs shall be either fuse protected or be Polymeric Positive Temperature Coefficient (PTC)-protected as per Class 2 UL listing.
10. Provide the following power data on submittals:
 - a. Input watts
 - 1) Power Factor (pf)
 - 2) Crest Factor (cf) at full input power
 - 3) Total Harmonic Distortion (THD).

B. Dimming Drivers:

1. LED driver shall be compatible with dimming controls where dimming is indicated on the Plans. Dimmable drivers shall use Dimming Constant Current (DCC), Constant Voltage, or Pulse Width Modulation (PWM) operation.
2. Step-Dimming Drivers: Easily switched from 0% to 50% to 100% output power. Both switch-leg inputs shall control 50% of the luminaire's light output equally.
3. Continuous Dimming Drivers: LED luminaires shall dim to (10%, 1%, or 0.1%) as specified in the Luminaire Schedule on the Plans without visible flicker or "popcorn effect". "Popcorn effect" is defined as the luminaire being on a pre-set dimmed level (less than 100%), and going to 100% prior to returning to the pre-set level when power is returned to the luminaire. Continuous Dimming Drivers shall use 0-10V control.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Verify ceiling types with Architectural plans or with existing ceilings. Verify specified luminaires are compatible with specified ceiling type(s) prior to ordering luminaires.
- B. Install in accordance with manufacturer's instructions.
- C. Install suspended luminaires using aircraft cable, or pendants supported from swivel hangers. Heavy-duty chain supports may be used where indicated on the luminaire schedule. Provide aircraft cable, pendants, or chain lengths required to suspend luminaire at indicated height. All aircraft cables or pendant supported luminaires shall have an independent support to structure at all cable or pendant support locations. When chain is used, tie-wrap the luminaire wiring method to the chain.
- D. Support luminaires larger than 2 x 4 foot (600 x 1200 mm) size independent of ceiling framing.
- E. Provide independent support for all luminaires over 50 lbs.
- F. Locate ceiling luminaires as indicated on reflected ceiling plan.
- G. Install surface mounted luminaires and exit signs plumb and adjust to align with building lines and with each other. Secure to prohibit movement.
- H. The Contractor shall install luminaire supports as required. Luminaire installations with luminaires supported only by insecure boxes will be rejected. It shall be the Contractor's responsibility to support all luminaires adequately, providing extra steel work for the support of luminaires if required. Any components necessary for mounting luminaires shall be provided by the Contractor. No plastic, composition or wood type anchors shall be used.
- I. Exposed Grid Ceilings: Support surface mounted luminaires on grid ceiling directly from building structure.
- J. Install recessed luminaires to permit removal from below.
- K. Install recessed luminaires using accessories and firestopping materials to meet regulatory requirements for fire rating.
- L. Install code required hardware to secure recessed grid-supported luminaires in place.
- M. Install wall mounted luminaires and exit signs at height as scheduled. Use pendants supported from swivel hangers in exposed ceiling/structure locations where necessary to mount exit signs at the specified height.
- N. Install accessories furnished with each luminaire.

- O. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.
- P. Bond luminaires and metal accessories to branch circuit equipment grounding conductor.
- Q. Install specified lamps in each luminaire and exit sign.
- R. HID High-Bay or Low-Bay Luminaires: Use power hook hangers rated 500 pounds (225 kg) minimum and provide safety chain between ballast and structure. Also provide safety chain between reflector and ballast.
- S. Dimmed luminaire circuits shall have separate neutrals.
- T. Dimmed LED luminaires shall have a positive OFF, which requires turning off the circuit to the luminaire so that the luminaires don't "glow" at the lowest dimmed setting. This shall be accomplished using a switch, relay, or some other means acceptable to DFD.
- U. All lamps shall be delivered to the job in sealed cartons and protected from dirt and dust during storage on the project. Lamps shall be taken directly from the cartons and installed in the luminaire with special care so that they do not become dusty and are not soiled in the operation.
- V. Lamps installed in luminaires using dimming ballasts shall be burned in at 100% rated output by the contractor for a minimum of 100 hours as recommended by the ballast manufacturer.
- W. All new lamps shall be operational at the Substantial Completion of the project.

3.02 ADJUSTING AND CLEANING

- A. Align luminaires and clean lenses and diffusers at completion of work. Clean paint splatters, dirt, and debris from installed luminaires.
- B. Aim and adjust luminaires as indicated on drawings or as directed by the A/E.
- C. Touch up luminaire finish at completion of work.

3.03 INTERFACE WITH OTHER PRODUCTS

- A. Interface with air handling accessories furnished and installed under Division 23.
- B. Provide controls as indicated on the plans. Refer to Section 26 27 26, "Wiring Devices". Controls shall be compatible with the luminaires/ballasts/drivers being installed.

3.04 ZERO-TO-10V DIMMING CONTROL WIRING INSTALLATION

- A. Zero-to-10V dimming control conductors are classified by the NEC as Class 2 conductors and shall be kept separate from line-voltage conductors per NEC

725.136(A). Matching the insulation rating of Conductors of Different Systems does not apply to Class 2 conductors per NEC 300.3(C)(1), Informational Note No.1.

- B. Wall box dimmers will typically have two conduits: One conduit for line-voltage power, and one conduit or conduit stub for the 0-10V control wiring.
- C. At each luminaire, separate openings (either manufactured knock-outs or punched openings) shall be used for the line-voltage power and the 0-10V wiring. The EC shall use a cable connector at the opening for the 0-10V wiring. Zero-to-10V conductors entering and within a luminaire enclosure shall maintain a minimum separation of 6 mm (0.25 in.) per NEC 725.136(D).
- D. Exposed 0-10V cables shall be installed in separate conduits from line-voltage conductors.
- E. The 0-10V cables may be routed in free air where concealed above accessible ceilings. Cables routed in free air shall observe the following installation requirements:
 - 1. The 0-10V cables may be tie-wrapped to the outside of the luminaire power raceway where allowed by NEC 300.11(B)(2). Tie-wraps shall be UL listed for UV resistance. Care should be taken in the use of cable ties to secure and anchor the cabling. Ties shall not be over tightened as to compress the cable jacket. No sharp burrs shall remain where excess length of the cable tie has been cut.
 - 2. Cabling shall be neatly run at right angles and be kept clear of other trades work.
 - 3. Cabling shall be secured within twelve (12) inches of direction change or termination.
 - 4. Cabling shall be supported at a maximum of 5-foot intervals utilizing “J-Hook” or “Bridle Ring” supports anchored to ceiling concrete, piping supports or structural steel beams. If cable sag at mid-span exceeds 12-inches, another support shall be provided. Cable supports shall be installed to maintain cable bend to larger than the minimum bend radius.
 - 5. Cabling shall not be attached to or supported by existing cabling, plumbing or steam piping, ductwork, suspended ceiling supports or electrical or communications conduit. Do not place cable directly on the ceiling grid or attach cable in any manner to the ceiling grid wires.
 - 6. All cables shall be free of tension at both ends. Nylon strain relief connectors shall be provided at each device and junction box where cables enter. In cases where the cable must bear some stress, Kellum type grips may be used to spread the strain over a longer length of cable.
 - 7. Cable manufacturer’s minimum bend radius shall be observed in all instances.
 - 8. Use suitable cable fittings and connectors.

3.05 FIELD QUALITY CONTROL

- A. Operate each luminaire after installation and connection. Inspect for proper connection and operation.

3.06 LUMINAIRE CONNECTIONS

A. Metal-Clad (MC) Cable Whips

1. Metal-Clad (MC) type cable that combines power and Class 2 circuits into a single cable may be used for luminaire whips where 0-10V dimming control wiring is required. Whips may not exceed six (6) feet in length. Examples of such products are Encore Wire® MC-LED™ or Southwire® MC-PCS Duo™. Manufacturer's names and catalog numbers are used for quality and performance only. MC Cables manufactured by others shall be equally acceptable provided they meet or exceed in performance and quality as specified.

B. Recessed, including Master-Satellite connections:

1. Use a luminaire fixture whip from a J-box for recessed lay-in luminaires. Luminaire fixture whips shall be aluminum or steel AC Cable (Armored Cable) or Flexible Metal Conduit (FMC). Metal Clad (MC) cable that combines power and Class 2 circuits (for 0-10V dimming control) into a single cable may be used as a whip for luminaires that are dimmed.
2. Cable/Conduit whips shall be 3/8" (10 mm) minimum diameter, six feet (1.8 m) maximum length.
3. Flexible whips or pre-wired systems between master and satellite luminaires may be supported by the ceiling grid wires.
4. The flexible connectors shall be steel, galvanized, clamp type with locknut, snap-in type with locknut, or snap-in connector type, including those used on the master-satellite units.

C. Chain or Cable Hung (unfinished spaces):

1. Use manufacturer's SO cord or a luminaire fixture whip from a J-box. Luminaire fixture whips shall be aluminum or steel AC Cable (Armored Cable) or Flexible Metal Conduit (FMC). Metal Clad (MC) cable that combines power and Class 2 circuits (for 0-10V dimming control) into a single cable may be used as a whip for luminaires that are dimmed.
2. Conduit whips shall be 3/8" (10 mm) minimum diameter. Conduit whip or SO cord shall be cut to length (six feet (1.8 m) maximum) and shall allow movement of the chain/cable/luminaire, but shall not be long enough to "loop" and shall present a neat and workmanlike appearance.
3. Luminaire field wired flexible cord installations shall be connected per NEC 410.62.
4. The flexible connectors shall be steel, galvanized, clamp type with locknut, snap-in type with locknut, or snap-in connector type, including those used on the master-satellite units.
5. Conduit whip slack shall be tie-wrapped to the chain supports. Tie-wraps shall be UL listed for UV resistance.

D. Cable Hung (finished spaces):

1. Use manufacturer's SO cord from luminaire to a J-box.
2. SO cord shall be cut to length (six feet (1.8 m) maximum) and shall allow movement of the cable/luminaire, but shall not be long enough to "loop" and shall present a neat and workmanlike appearance.
3. SO cord slack may be tie-wrapped to the cable supports. Tie-wraps shall be UL listed for UV resistance.

4. Luminaire field wired flexible cord installations shall be connected per NEC 410.62.
- E. Surface Mounted (unfinished spaces): Provide direct conduit and box connection.
- F. Surface Mounted (finished spaces): Provide direct conduit and box connection. Use surface metal raceway where indicated on drawings. Conceal box and conduit where appropriate. Flexible metal conduit shall not be used where the conduit is exposed.

END OF SECTION

SECTION 26 56 00 SITE LIGHTING

PART 1 - GENERAL

1.01 SCOPE

- A. The work under this section Site Lighting includes exterior luminaires and accessories, poles, and foundations.

1.02 REFERENCE STANDARDS

- A. International Building Code IBC 1807.3 Embedded Posts and Poles
- B. RoHS – Restriction of Hazardous Substances. Council of the European Union (EC) Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment.
- C. LM-79-08 (or latest) – IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
- D. LM-80-08 (or latest) – IES Approved Method for Measuring Lumen Maintenance of LED Light Sources.
- E. TM-21-11 (or latest) – IES Technical Memorandum on Projecting Long Term Lumen Maintenance of LED Light Sources.
- F. NEMA SSL 1-2010 (or latest) – Electronic Drivers for LED Devices, Arrays, or Systems.

1.03 DEFINITIONS

- A. Driver: The power supply used to power LED luminaires, modules, or arrays.
- B. L70, L₇₀, or L_{70%}: The reported life of an LED component or system to reach 70% lumen maintenance, or 70% of the LEDs original light output. This test is being developed by the IES and is currently described by TM-21-11.
- C. LEDs: Broadly defined as complete luminaire with light emitting diode (LED) packages, modules, light bars or arrays, complete with driver.
- D. LED luminaire failure: Negligible light output from more than 10 percent of the LEDs constitutes luminaire failure.

1.04 SUBMITTALS

- A. Shop Drawings: Indicate dimensions and components for each luminaire, pole and base.

B. Product Data:

1. For each luminaire type, submit luminaire information including catalog cuts with highlighted catalog numbers, and required accessories:
 - a. Luminaire:
 - 1) Manufacturer and catalog number,
 - 2) Type (identification) as indicated on the plans and schedule,
 - 3) Delivered lumens,
 - 4) Input watts,
 - 5) Efficacy,
 - 6) Color rendering index,
 - 7) Performance data, and
 - 8) Effective Projected Area (EPA).
 - b. Driver:
 - 1) Manufacturer and catalog number,
 - 2) Type (Non-Dimming, Step-dimming, Continuous dimming, etc.),
 - 3) Power Factor, Crest Factor, THD, etc.
 - c. Pole (if applicable):
 - 1) Diameter
 - 2) Height
 - 3) Pole thickness
 - 4) Weight

C. Manufacturer's Instructions:

1. Indicate application conditions and limitations of use stipulated by product testing agency specified under "Regulatory Requirements".
2. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

D. Light Layout: Provide a computer-generated factory point-by-point foot-candle layout of the project for each area involved.

E. Post Installation Report: Provide to the Engineer the results of the measured foot-candle level for each area involved.

1.05 PROJECT RECORD DOCUMENTS

- A. Accurately record actual locations of each luminaire, pole, and underground circuit.
- B. Provide record drawings of the final, as installed and measured, point-by-point foot-candle layout for each area involved.

1.06 OPERATION AND MAINTENANCE DATA

- A. All operations and maintenance data shall comply with the submission and content requirements specified under Section General Requirements.

1.07 COORDINATION

- A. Use bolt templates and pole mounting accessories to install anchor bolts in pole base.

1.08 EXTRA MATERIALS

- A. Provide three (3) percent of each lamp type, but not less than one (1) of each type.
- B. Provide one (1) of each type of LED module, light bar, or array (if applicable). If the LEDs are integrated into the luminaire and are not separate components, then provide one (1) of each of these types of luminaires.
- C. Provide one (1) LED driver of each type.
- D. Provide five (5) percent of total fuses provided for each size, but not less than one (1) of each size.

PART 2 - PRODUCTS

2.01 LUMINAIRES

- A. See the Luminaire Schedule on the drawings for type of luminaires and catalog numbers. Catalog numbers are shown on the drawings for quality and performance requirements only. Luminaires manufactured by others are equally acceptable provided they meet or exceed the performance of the indicated luminaires, and meet the intent of the design.
- B. Luminaire shall be certified by a Nationally Recognized Testing Laboratory (UL, ETL, or IEC).
- C. Provide luminaires with quick-connect disconnecting means, similar to Thomas & Betts Sta-Kon.

2.02 LED LUMINAIRES

- A. LED Luminaires shall meet all DesignLights Consortium® (DesignLights.org) Product Qualification Criteria. This does not require that the luminaire be listed on the DesignLights Consortium's® Qualified Products List, but they must meet the Product Qualification Criteria. The technical requirements that the luminaire shall meet for each Application Category are:
 - 1. Minimum Light Output.
 - 2. Zonal Lumen Requirements.
 - 3. Minimum Luminaire Efficacy.
 - 4. Minimum CRI.
 - 5. L70 Lumen Maintenance.
 - 6. Minimum Luminaire Warranty of 5 years (not pro-rated) to include LED driver and all LED components.

- B. Color Temperature of 3000K-4100K for interior luminaires as listed in the Luminaire Schedule on the Plans. The color temperature of exterior LED luminaires should not exceed 4100K (nominal).
- C. Color Consistency: LED manufacturer shall use a maximum 3-step MacAdam Ellipse binning process to achieve consistent luminaire-to-luminaire color for interior luminaires. Exterior luminaires shall use a maximum 5-step MacAdam Ellipse binning process.
- D. Glare Control: Exterior luminaires shall meet DesignLights Consortium's® criteria for Zonal Lumen Distribution requirements or Backlight-Uplight-Glare (BUG) standards for exterior luminaires.
- E. Luminaire shall be mercury-free, lead-free, and RoHS compliant.
- F. Luminaire shall comply with FCC 47 CFR part 15 non-consumer RFI/EMI standards.
- G. Light output of the LED system shall be measured using the absolute photometry method following IES LM-79 and IES LM-80 requirements and guidelines.
- H. Luminaire shall maintain 70% lumen output (L70) for a minimum of 50,000 hours.
- I. Lumen output shall not depreciate more than 20% after 10,000 hours of use.
- J. Luminaire and driver shall be furnished from a single manufacturer to ensure compatibility.
- K. Luminaire Color Rendering Index (CRI) shall be a minimum of 80 for interior luminaires, and a minimum of 70 for exterior luminaires.
- L. LED luminaire shall be thermally designed as to not exceed the maximum junction temperature of the LED for the ambient temperature of the location the luminaire is to be installed. Rated case temperature shall be suitable for operation in the ambient temperatures typically found for the intended installation. Exterior luminaires to operate in ambient temperatures of -40°F to 104°F (-40°C to 40°C).
- M. Luminaire shall operate normally for input voltage fluctuations of plus or minus 10 percent.
- N. Luminaire shall have a maximum Total Harmonic Distortion (THD) of $\leq 20\%$ at full input power and across specified voltage range.
- O. All connections to luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.
- P. All luminaires shall be provided with knockouts for conduit connections.

- Q. The LED luminaire shall carry a limited 5-year warranty minimum for LED light engine(s)/board array, and driver(s).
- R. Provide all of the following data on submittals:
 - 1. Delivered lumens
 - 2. Input watts
 - 3. Efficacy
 - 4. Color rendering index.
- S. LED Luminaires used for Emergency Egress Lighting: The failure of one LED shall not affect the operation of the remaining LEDs.
- T. Emergency LED Luminaire Compatibility with Inverters: Emergency Inverters shall be sine-wave type, or have written confirmation from the luminaire manufacturer that the luminaire will function with a square-wave inverter.

2.03 LED DRIVERS

- A. General:
 - 1. Provide driver type (non-dimmed, step-dimmed, continuous-dimming, etc.) as indicated on the luminaire schedule on the drawings.
 - 2. Minimum Warranty of 5 years (not pro-rated) to include LED driver and all LED components.
 - 3. Driver shall have a rated life of 50,000 hours, minimum.
 - 4. Driver and LEDs shall be furnished from a single manufacturer to ensure compatibility.
 - 5. Driver shall have a minimum power factor (pf) of 0.9 and a maximum crest factor (cf) of 1.5 at full input power and across specified voltage range.
 - 6. Driver shall operate normally for input voltage fluctuations of plus or minus 10 percent.
 - 7. Driver shall have a maximum Total Harmonic Distortion (THD) of $\leq 20\%$ at full input power and across specified voltage range.
 - 8. Wiring connections to LED drivers shall utilize polarized quick-disconnects for field maintenance.
 - 9. Fuse Protections: All luminaires shall have built-in fuse protection. All power supply outputs shall be either fuse protected or be Polymeric Positive Temperature Coefficient (PTC)-protected as per Class 2 UL listing.
 - 10. Provide all of the following data on submittals:
 - a. Input watts
 - b. Power Factor (pf)
 - c. Crest Factor (cf) at full input power
 - d. Total Harmonic Distortion (THD).
- B. Dimming Drivers:
 - 1. LED driver shall be compatible with dimming controls where dimming is indicated on the plans. Dimmable drivers shall use Dimming Constant Current (DCC), Constant Voltage, or Pulse Width Modulation (PWM) operation.

2. Step-Dimming Drivers: Easily switched from 0% to 50% to 100% output power. Both switch-leg inputs shall control 50% of the luminaire's light output equally.
 3. Continuous Dimming Drivers: LED luminaires shall dim to (20%, 15%, 10%, 5%, or 0.1%) as specified in the Luminaire Schedule on the plans without visible flicker or "popcorn effect". "Popcorn effect" is defined as the luminaire being on a pre-set dimmed level (less than 100%), and going to 100% prior to returning to the pre-set level when power is returned to the luminaire. Continuous Dimming Drivers shall use 0-10V control.
- C. Drivers for Bi-Level Switching:
1. Drivers shall be compatible with bi-level switching control by motion sensors where indicated on the drawings.

2.04 MOTION SENSORS FOR BI-LEVEL SWITCHING

- A. Provide luminaires with motion sensors for bi-level switching as indicated on the drawings. Luminaires shall normally operate at a low level during nighttime hours, but shall increase to 100% output when they sense motion. Motion sensor shall be selected based on pole/mounting height, coverage area, and shall be suitable for operation in the ambient temperatures typically found for the intended installation. Luminaire shall be compatible with bi-level switching operation.

2.05 FUSES

- A. Furnish and install a fuse holder and fuse in each ungrounded leg of the electrical circuit supplying the outdoor luminaire. If the voltage is 208, 240, or 480 volts, then the fuse holder needs to be a 2-pole fuse holder which simultaneously disconnects both ungrounded conductors. Every luminaire (including bollards) shall be separately fused with a water-resistant fuse holder. Size the fuse for the amperage of the luminaire. Tap the circuit conductors with a minimum #10 AWG conductor to serve the luminaire. The fuse and holder shall be accessible through the handhole. Provide sufficient wire to bring fuse holder outside of handhole.

2.06 WIRING CONNECTORS

- A. Wiring Connectors shall meet the requirements of Section 26 05 19 Wiring/Cable, 600 Volts and Under.
- B. Twist-On Wire Connectors: Solderless twist-on spring connectors (wire-nuts) with insulating covers for copper wire splices and taps. All wire connectors used in site lighting applications shall be silicone gel-filled twist connectors or connectors designed for damp and wet locations. Gel-filled twist-on connectors may be used for copper conductor sizes 6 AWG and smaller for site lighting applications. The manufacturer's wire fill capacity must be followed.

2.07 POLES

- A. Provide poles designed for wind loading of 100 miles per hour determined in accordance with AASHTO LTS2 while supporting luminaires having effective projected areas indicated. Poles shall be anchor base type designed for use with underground supply conductors.
- B. Concrete Poles: Provide concrete poles conforming to PCI JR275 5/6 and as follows:
 - 1. Steel Reinforcing: Prestressed concrete pole shafts shall be reinforced with steel prestressing members. The design shall provide internal longitudinal loading by either pretensioning or posttensioning of the longitudinal reinforcing members.
 - 2. Primary Reinforcing: Primary (Longitudinal) reinforcing steel used in prestressed concrete poles shall be high strength, stress relieved uncoated wire type, either stranded or solid in accordance with ASTM A416 or ASTM A421.
 - 3. Supplementary Reinforcing: Supplementary reinforcing steel, if required, may be of either high strength or of medium strength steel in accordance with ASTM A416 (75,000 psi min).
 - 4. Tensioned Reinforcing: The primary reinforcement steel used for a prestressed concrete pole shaft shall be tensioned to 60 percent to 70 percent of its ultimate strength. The amount of reinforcement shall be such that when reinforcement is tensioned to 70 percent of its ultimate strength, the total resultant tensile force does not exceed the minimum section compressive strength of the concrete.
 - 5. Coating and Sleeves For Reinforcing Members: Reinforcing steel shall be spaced and secured so as to insure a minimum concrete coverage of 1/2 inch thickness. Where minimum internal coverage cannot be maintained next to required core openings, such as handhole and wiring inlet, the reinforcing shall be protected with a vapor-proof noncorrosive sleeve over the length without the 1/2 inch concrete coverage. Each steel reinforcing member which is to be posttensioned shall have a non-migrating slipper coating applied prior to the addition of concrete to insure the uniformity of stress throughout the length of such member.
 - 6. Cement Mix: The cement used for the concrete shall be Portland cement in accordance with ASTM C150. Types I or III shall be used for general service. However, if resistance to sulfates is necessary, Portland cement Types II or V may be substituted.
 - 7. Aggregate: The aggregate used for the concrete shall be fine grade, either natural or artificial. Natural aggregate shall conform to ASTM C33, fine grade except that five to ten percent shall be retained by a number 4 sieve. Artificial aggregates shall conform to applicable sections of ASTM C33 and ASTM C330 regarding size and strength. Either type shall have been proven for the following:
 - a. Moisture absorption, two percent maximum of weight.
 - b. Good resistance to abrasion.
 - 8. Water: The water used for concrete shall be clean and free of injurious quantities of substances deleterious to concrete or to prestressing steel.

9. Strength Requirement: The proportions of cement, aggregate, and water for the concrete, and the processing and curing of the concrete, shall be such as to develop a minimum compressive strength of 3500 psi before stress transfer in prestressing. Further natural curing shall achieve a 28 day compressive strength of 7000 psi. Poles shall not be subjected to severe temperature changes during the curing period.
 10. Shaft Preparation: The completed prestressed concrete pole shaft shall be clean, smooth, and free of surface voids and internal honeycombing.
- C. Aluminum Poles: Provide aluminum poles manufactured of corrosion resistant aluminum alloys conforming to AASHTO LTS2 for Alloy 6063 T6 or Alloy 6005 T5 for wrought alloys and Alloy 356 T4 (3,5) for cast alloys. Poles shall be seamless extruded or spun seamless type. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire.
 - D. Steel Poles: AASHTO LTS2. Provide steel poles having minimum 11 gage steel with minimum yield/strength of 48,000 psi and hot dipped galvanized per ASTM A123 factory finish. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire.
 - E. Handhole: With removable weatherproof cover.
 - F. Anchor Bolts: As recommended by pole manufacturer. Provide template, flat washers, lock washers, and hex nuts for each pole.

2.08 FOUNDATIONS

- A. Provide foundations for poles, bollards, and ground-mounted flood and accent lighting. Construct from reinforced concrete in sizes as shown on drawings and to meet the minimum structural requirements of SPS 362.1807 Shallow Post Foundations, and IBC 1807.3 Embedded Posts and Poles.
- B. Place the anchor bolts in pole bases so that the luminaire will be oriented perpendicular to the curb/street/sidewalk/parking lot or as indicated on the plan.
 1. Provide a concrete-encased electrode (UFER) grounding system for grounding the foundation, luminaire, and pole:
 2. Provide twenty-five (25) feet of #4 bare stranded copper grounding electrode conductor.
 3. Extend three (3) feet of the grounding electrode conductor out the top of the foundation for connection to the luminaire/pole.
 4. Clamp the grounding electrode conductor to the top of the rebar cage. Use a clamp rated for such use such as an Erico EK16 or similar.
 5. Spiral a minimum of ten (10) feet of the grounding electrode conductor around the outside of the rebar cage.
 6. Loop the remaining conductor around the rebar cage at the bottom of the foundation in direct contact with earth.
- C. The exposed surface area of the foundation shall have the forms removed and the concrete rubbed out to a smooth finish.

- D. Pole Base J-Boxes: For pole bases with multiple conduits to other poles/locations, the contractor may provide a non-metallic j-box with a curved cover mounted in the side of the exposed part of the base to accommodate the multiple conduits. Boxes shall be NEMA 3R Carlon Nonmetallic Curved Lid J-Boxes or equal. Mount j-box centered at 20" above grade. Use only in poles 18" in diameter and larger. Locate boxes 90-degrees or 180-degrees from traffic. Install boxes per manufacturer's recommendations.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Aluminum and Steel Poles: Provide anchor bases with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end. Provide galvanized nuts, washers, and ornamental covers for anchor bolts. Thoroughly compact backfill with compacting arranged to prevent any pressure between conductor, jacket, or sheath and the end of conduit ell. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location. After installation, paint the exposed surfaces of steel poles with two finish coats of exterior oil paint of a color as indicated.
- B. Pole Setting: Depth shall be as indicated. Dig holes large enough to permit the proper use of tampers to the full depth of the hole. Place backfill in the hole in 6 inch maximum layers and thoroughly tamp. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.
- C. Install in accordance with manufacturers' instructions.
- D. Minimum underground conduit size is 1 inch unless otherwise indicated.
- E. Underground and exterior wire shall be minimum #8 AWG conductors, type XHHW-2. #10 AWG conductors shall be utilized for vertical wire installed within pole and for overall circuit lengths of less than 100 LF.
- F. Protect anchor bolts 2 inches (50 mm) minimum above base.
- G. Install all anchor bolts and handhole fasteners with anti-seize compound.
- H. Install poles plumb. Provide shims or double nuts to adjust plumb.
- I. Use belt slings or non-chafing ropes to raise and set pre-finished luminaire poles.
- J. Bond each luminaire, each metal accessory, the ground rod and the pole to the branch circuit equipment ground conductor with a separate ground wire sized per NEC or as shown on the drawings.
- K. Dimmed luminaire circuits shall have separate neutrals.
- L. Dimmed luminaires shall have a positive OFF, which requires turning off the circuit to the luminaire so that the luminaires do not "glow" at the lowest dimmed

setting. This shall be accomplished using a switch, relay, or some other means acceptable to Engineer.

3.02 FIELD QUALITY CONTROL

- A. Operate each luminaire after installation and connection. Inspect for improper connections and operation.

3.03 ADJUSTING

- A. Aim and adjust luminaires as indicated on drawings or as required to meet the performance specifications.
- B. All new lamps shall be operational at the Substantial Completion of the project.
- C. Adjust motion sensors to provide proper coverage for bi-level switching operation.

3.04 CLEANING

- A. Clean photometric control surfaces.
- B. Clean finishes and touch up damage.

END OF SECTION