#### **SECTION 260500**

### COMMON WORK RESULTS FOR ELECTRICAL

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. The requirements contained in this Section apply to all Sections of this Division.
- B. Section Includes:
  - 1. Common terminology and requirements used throughout this Division.
  - 2. Requirements for Acceptance Testing Agency.
  - 3. Requirements for Professional Engineers responsible for Delegated Design.
  - 4. Electrical equipment coordination and installation.
  - 5. Sleeves for raceways and cables.
  - 6. Sleeve seals.
  - 7. Grout.
  - 8. Common electrical installation requirements.

#### 1.2 DEFINITIONS

- A. AHJ: Authorities Having Jurisdiction.
- B. ANSI GRAY: Where this Section and other Sections of this Division use the term "ANSI GRAY" it shall mean the manufacturer's standard ANSI Gray.
- C. Bound Material: Bound refers to materials permanently bound, as by stitching or glue, or materials securely fastened in their covers by multiple fasteners that penetrate all papers. Ring binders, spiral binders, brads and screw posts are acceptable fasteners. Loose papers clipped together or stapled at one corner are not acceptable.
- D. Business Day: Where this Section and other Sections of this Division use the term "Business Day" it shall mean Monday thru Friday, excluding Holidays recognized by Federal, State and Local government.
- E. EPDM: Ethylene-propylene-diene terpolymer rubber.
- F. FMS: Facility management system.
- G. NETA ATS: Acceptance Testing Specification, as published by InterNational Electrical Testing Association.

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- H. NBR: Acrylonitrile-butadiene rubber.
- I. NIST: National Institute of Science and Technology.
- J. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.
- K. RS-485: A TIA standard for multipoint communications using two twisted-pairs.
- L. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
- 1.3 INNOVATION MEMORANDUMS
  - A. The Owner has obtained purchase agreements for select equipment and materials. These purchase agreements are documented as Innovation Memorandums and are to be included as part of this project.
    - 1. Innovation Memorandum No. 5: All lighting fixtures and accessories to be purchased from Graybar Electric Supply in Nashville, TN. Contact Charlie Shannon, office (615) 743-3226, or email <u>HCA@graybar.com</u>. Refer to Division 26 Sections Interior Lighting" and "Exterior Lighting".
    - Innovation Memorandum No. 16: Electrical products including, but not limited to, power distribution, wire, and conduit to be purchased from Graybar Nashville. Contact Charlie Shannon, 825 8<sup>th</sup> Avenue South, Nashville, TN 37217, (615) 743-3226, or email <u>HCA@graybar.com</u>. Refer to Division 26 Sections:
      - a. "Low-Voltage Electrical Power Conductors and Cables"
      - b. "Grounding and Bonding for Electrical Systems"
      - c. "Hangers and Supports for Electrical Systems"
      - d. "Raceways and Boxes for Electrical Systems"
      - e. "Pathways for Special Systems"
      - f. "Underfloor Raceways for Electrical Systems"
      - g. "Underground Ducts and Raceways for Electrical Systems"
      - h. "Vibration and Seismic Control for Electrical System"
      - i. "Identification for Electrical Systems"
      - j. "Overcurrent Protective Device Coordination Study"
      - k. "Electrical Power Monitoring and Control"
      - 1. "Lighting Control Devices"

- m. "Network Lighting Control"
- n. "Low-Voltage Transformers"
- o. "Switchboards"
- p. "Panelboards"
- q. "Electrical Cabinets and Enclosures"
- r. "Wiring Devices"
- s. "Fuses"
- t. "Enclosed Switches and Circuit Breakers"
- u. "Enclosed Controllers"
- v. "Central Battery Equipment"
- w. "Surge Protective Devices".
- 3. Innovation Memorandum No. 25: Project shall comply with 2022r2 MEP Guidelines.

# 1.4 PERFORMANCE REQUIREMENTS

A. The Drawings diagrammatically show the sizes and locations of various equipment and devices, and the sizes of the major interconnecting wires, without showing exact details as to elevations, offsets, control wiring and other installation requirements. Carefully layout the Work at the site to conform to the architectural and structural conditions, to avoid obstructions and to permit proper grading of pipe associated with other portions of the Work. In cooperation with other trades, determine the exact location of equipment and devices and connections thereto by reference to the submittals and rough-in drawings, and by measurements at the site. Make minor relocations necessitated by the conditions at the site, or directed by the Owner, without additional cost to the Owner.

# 1.5 SUBMITTAL PROCEDURES

- A. Common Requirements for Product Data: Where this Section and other Sections of this Division require Product Data to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures". In addition to the requirements of Division 01 comply with the following:
  - 1. Submit Product Data in electronic format. Files shall be provided in Portable Document Format (.pdf).
    - a. Submit digital copies of Product Data as required under Division 01.
    - b. Bookmark Portable Document Format (.pdf) files of digital copies with a unique section identification heading for ease of navigation.

- 2. In addition to digital copies, hardcopies of Product Data may be required, verify with Division 01. If hardcopies are required, they shall have each sheet clearly labeled with a unique sheet identification number.
- 3. Product Data shall not consist of manufacturer's catalogs or cut sheets that contain no indication of the exact item offered. The submission on individual items shall designate the exact item offered.
- B. Common Requirements for Shop Drawings and Coordination Drawings: Where this Section and other Sections of this Division require Shop Drawings or Coordination Drawings to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures" and Division 01 Section "Project Management and Coordination". In addition to the requirements of Division 01 comply with the following:
  - 1. Prepare Shop Drawings and Coordination Drawings in accordance with project's approved BIM Management Plan.
  - 2. Prepare Shop Drawings and Coordination Drawings using computerized modeling software compatible with AutoDesk's Revit®, AutoCAD®, or Navisworks®. Drawings files must be composite with multiple distinctive layers for each of the various trades.
  - 3. Shop Drawings and Coordination Drawings shall be of appropriate scale but shall not be smaller than a scale of 1/4-inch equals one foot.
  - 4. Coordination Drawings shall be multi-color prints with each system printed in a separate and unique color.
  - 5. Submit Shop Drawings and Coordination Drawings in electronic format. Files shall include both AutoDesk® compatible source files and files printed to Portable Document Format (.pdf).
    - a. Submit digital copies of Shop Drawings and Coordination Drawings as required under Division 01.
    - b. Bookmark Portable Document Format (.pdf) files of digital copies with a unique sheet identification number for ease of navigation.
  - 6. In addition to digital copies, hardcopies of Shop Drawings or Coordination Drawings may be required, verify with Division 01. If hardcopies are required, they shall have each sheet clearly labeled with a unique sheet identification number.
- C. Common Requirements for Specification Compliance Certification: Where this Section and other Sections of this Division require Specification Compliance Certification to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures" for "Other Informational Submittals". In addition to the requirements of Division 01 comply with the following:
  - 1. Prepare a line-by-line Specification Compliance Certification by marking up a copy of the Contract Document specification section in the left margin. Accompany the markup with a written report explaining all items that are not marked with "Compliance". Submit

line-by-line markup, written report of deviations and alternates and a cover letter certified by Manufacturer or Installer that prepared the Specification Compliance Certification. Use the following key for preparing the line-by-line markup.

- a. "C" for Compliance: By noting the term "compliance" or "C" in the margin, it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.
- b. "D" for Deviation: By noting the term "deviation" or "D" in the margin, it shall be understood that the manufacturer prefers to provide a different component in lieu of that specified.
- c. "A" for Alternate: By noting the term "alternate" or "A" in the margin, it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner.
- d. "N/A" for Not Applicable: By noting the term "not applicable" or "N/A" in the margin, it shall be understood that the specified item is not applicable to the project.
- D. Common Requirements for Qualification Data:
  - 1. Professional Engineer Qualifications: Where this Section and other Sections of this Division require a Professional Engineer to be responsible for Delegated Design requirements; Submit Qualification data for Professional Engineer including, but not limited to, proof of registration in the Project location.
  - 2. Independent Testing and Inspecting Agency Certification: Where this Section and other Sections of this Division require an Independent Testing and Inspecting agency to be responsible for Acceptance Testing and Field Quality Control requirements; Submit certification documentation for such agency that demonstrates compliance with the Quality Assurance paragraph of this Section.

#### 1.6 ACTION SUBMITTALS

- A. Product Data: Submit product data for each of the following.
  - 1. Sleeves.
  - 2. Sleeve seals.
  - 3. Grout.

# 1.7 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Prepare drawings showing dimensioned layout for the following:
  - 1. Penetration and Structural Opening: Floor plans showing sleeves and formed structural penetrations. Show sleeve and formed penetration layouts and relationships between

structural components and other adjacent building elements, including but not limited to pre-tensioning and post-tensioning members where used.

- 2. Reflected Ceiling Plans: ceiling plans, sections, and other necessary details showing dimensioned layouts for equipment located in or on the ceiling plane. Base dimensions on exact dimensioned data obtained from product submittals for products to be included in the Work. Differentiate between field measurements and assumed dimensions. Include the following items coordinated with each other, based on input from installers of the items involved:
  - a. Suspended ceiling components.
  - b. Structural members to which suspension systems for luminaires will be attached.
  - c. Perimeter moldings, decorative ceiling elements, and Architectural features.
  - d. Luminaires.
  - e. HVAC Diffusers, Registers and Grilles.
  - f. Speakers.
  - g. Sprinklers.
  - h. Fire Alarm initiating devices, including but not limited to the following:
    - 1) Smoke detectors.
    - 2) Heat detectors.
    - 3) Flame detectors.
  - i. Fire Alarm notification appliances.
  - j. Occupancy sensors.
  - k. Access panels.
  - 1. Security cameras and occupancy detectors.
  - m. Wireless Access Points.
  - n. Nurse Call Zone and Dome Lights.
  - o. Patient Telemetry Receivers and Equipment.
- 3. Electrical Equipment Layouts: Floor plans, elevations, and other necessary details showing dimensioned layouts for spaces containing electrical equipment. Base electrical equipment dimensions on exact dimensioned data obtained from product submittals for products to be included in the Work. Differentiate between field measurements and

assumed dimensions. Include the following items coordinated with each other, based on input from installers of the items involved:

- a. Electrical equipment layout and relationships between components and adjacent structural and mechanical elements.
- b. Indication of required working clearances and required area above and around electrical equipment where pipes and ducts are prohibited.
- c. Location of Conduit entry into electrical equipment.
- d. Location of luminaires, sprinkler piping and heads, ducts, and diffusers.
- e. Electrical equipment support locations, type of support, and weight on each support.
- f. Location of structural supports for structure-supported raceways.
- g. For floor mounted equipment: concrete base dimension, outline of equipment, and required clearances.

#### 1.8 QUALITY ASSURANCE

- A. Common Requirements for Independent Testing and Inspecting Agency Qualifications: Where this Section and other Sections of this Division call for an Independent Testing and Inspecting Agency (Testing Agency); the Testing Agency shall comply with the following requirements:
  - 1. Have the experience and capability to conduct the testing indicated,
  - 2. Be a member company of the InterNational Electrical Testing Association (NETA) or a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction and the Engineer-of-Record.
  - 3. Meet the Requirements of NETA ATS 3.0 including, but not limited to, the following:
    - a. Be an independent, third party entity which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems being evaluated.
    - b. Be regularly engaged in the testing electrical equipment devices, installations, and systems.
    - c. Use technicians who are regularly employed for testing services.
    - d. Have a "Full Membership" classification issued by the InterNational Electrical Testing Association meets the above criteria.
  - 4. Testing Agency's Field Personnel: Technicians performing specified electrical tests and inspections shall meet the Requirements of NETA ATS 3.0 including, but not limited to, the following:

- a. Technicians performing specified electrical tests and inspections shall be trained and experienced concerning the apparatus and systems being evaluated. These individuals shall be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved. They must evaluate the test data and make a judgment on the serviceability of the specific equipment.
- b. Technicians shall be certified in accordance with ANSI/NETA ETT-2000, Standard for Certification of Electrical Testing Personnel. Each on-site crew leader shall hold a current certification, Level III or higher, in electrical testing.
- B. Common Requirements for Material Quality: Materials, equipment and devices shall be new and of the quality specified, and shall be free from defects at the time of installation. Materials, equipment and devices damaged in shipment or otherwise damaged or found defective prior to acceptance by the Owner shall be replaced with new materials, equipment or devices identical with those damaged, unless approved otherwise by the Owner in writing.
- C. Common Requirements for Code Compliance: In case where differences occur between building codes, state laws, local ordinances, industry standards, utility company regulations and the Contract Documents, the most stringent shall govern. Perform the following:
  - 1. Promptly notify the Architect in writing of any such difference.
  - 2. Obtain approval from Architect before proceeding with the Work.
  - 3. Should the Contractor perform any work that knowingly does not comply with local codes, laws and ordinances, industry standards, or other governing regulations; the Work shall be corrected at no cost to the Owner.
- D. Common Requirements for Compliance with AHJ Instructions: In cases where the Authority Having Jurisdiction requires deviations from the requirements of the Contract Documents, perform the following:
  - 1. Promptly notify the Architect in writing of any such difference.
  - 2. Obtain approval from Architect before proceeding with the Work.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - 1. Wherever a UL standard has been established for a particular type of material, equipment or device, each item of such material, equipment or device provided shall meet the requirements of the UL standard.

# 1.9 PRODUCT SUBSTITUTIONS

A. Comply with provisions of Division 01 Section "Product Requirements and Product Substitution Procedures".

- 1. If item of equipment or device offered as Substitution differs in dimension or configuration from that indicated in the Contract Documents, provide, as part of the substitution submittal, a drawing that shows that the equipment or devices proposed for Substitution can be installed in the space available without interfering with other trades or with access requirements for operations and maintenance in the completed project. Drawings shall be of appropriate scale but shall not be smaller than a scale of 1/4-inch equals one foot.
- 2. Where substitute equipment or devices requires different arrangement or connections from that indicated in the Contract Documents, install the equipment or devices to operate properly and in accordance with the requirements of the Contract Documents. Make incidental changes necessary in piping, ductwork or wiring which results from the inclusion of the substitute equipment or device without any additional cost to the Owner. Pay all additional costs incurred by other trades in connection with changes required by the inclusion of the substitute equipment or device in the Work.

### 1.10 PROJECT CONDITIONS

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
  - 1. Notify Construction Manager and Owner no fewer than five business <Insert number> days in advance of proposed interruption of electrical service.
  - 2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's written permission.
- B. Schedule of Work in Existing Facilities:
  - 1. The building will continue in use throughout the construction period, carry out the Work in such a manner as to minimize disturbance to the occupants.
  - 2. The schedule contemplates working in designated areas in the existing building while other adjacent areas are still being occupied. Carry out the Work in such a manner as to minimize disturbance to those occupied areas.
  - 3. Should the Work in the designated areas affect any services to the areas that are to remain in use, new permanent or temporary services or a combination of both shall be installed as required to enable those occupied areas to function properly and without interruption.
  - 4. Perform no work in the existing building which would interfere with its use during normal hours of occupancy, Including but not limited to operations which would cause objectionable noise or service interruptions, unless special permission is granted by the Owner.
- C. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving large equipment into place. Where any piece of equipment is too large for ingress through normal building openings it shall be placed in its containing space before the enclosing structure is completed.

D. Temporary Power: Where temporary power is required during the construction period, comply with ANSI/NECA 200 "Recommend Practice for Installing and Maintaining Temporary Power at Construction Sites."

# 1.11 COORDINATION

- A. In describing various materials, equipment and devices, in general each item may be described singularly, even though there may be a multiplicity of identical items. Also, where the description is general in nature, the exact sizes, duties, space arrangements, horsepower and other requirements must be obtained by reference to other portions of Contract Documents.
- B. Space allocations for materials, equipment and devices have been made on the basis of present and known future requirements and the dimensions of items of equipment or devices of a particular manufacturer. Verify that all materials, equipment and devices proposed for use on this Project are within the constraints of the allocated space.
- C. Coordinate arrangement, mounting, and support of electrical equipment:
  - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
  - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
  - 3. To allow right of way for piping, ductwork and conduit installed at required slope.
  - 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- D. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- E. Utility Service Coordination:
  - 1. Electrical Service: Coordinate the location of the electrical service entrance with the electric utility company and with other trades. Provide materials and equipment required to connect the electrical service.
- F. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- G. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- H. For roof-mounted equipment: Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

### 1.12 CONTRACTOR'S USE OF CAD/REVIT FILES

- A. At the Contractor's written request, copies of the Engineer's CAD / Revit files may be made available for Contractor use in connection with the project, subject to following conditions:
  - 1. Submit written request to the Architect listing the specific drawings the Contractor is requesting. Provide a specific list of submittals that the files will be used in preparing, and the list of names of subcontractors or suppliers.
  - 2. The Contractor shall request in writing the electronic transfer agreement. Prior to transfer of files, the Contractor shall prepare a separate electronic transfer agreement for each subcontractor or supplier who will be using the electronic files.
  - 3. Data contained on the electronic files is part of WSP USA Buildings, Inc. (WSP) instruments of service and shall not be used for any purpose other than as a convenience in the preparation of shop drawings for the referenced project. Any other use or reuse will be at the Contractor's sole risk and without liability or legal exposure to WSP.
  - 4. The electronic files are not contract documents. Significant differences may exist between the electronic files and the corresponding hard copy contract documents. Because of the possibility the information and data delivered in machine readable form may be altered, whether inadvertently or otherwise, WSP reserves the right to retain hard copy originals of the electronic documentation delivered to the contractor, in machine readable form, which the original shall be referred to and shall govern in the event of any inconsistency between the two.
  - 5. The use of the electronic files, does not relieve the Contractor of their duty to fully comply with the contract documents, including and without limitation, the need to check confirm and coordinate all dimensions and details, take field measurements, verify field conditions and coordinate work with that of other Contractors for the project.
  - 6. All "internal" calculations integral to / performed by the Revit model shall not be utilized for any purpose by the Contractor. This includes, but shall not be limited to, voltage drop calculations, duct static pressure calculations, air system airflow summary calculations, piping system pressure drop calculations, etc.
  - 7. All Revit "families" are the property of WSP and shall not be re-used on any other project for any purpose by the Contractor.

# PART 2 - PRODUCTS

### 2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.

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- 1. Minimum Metal Thickness:
  - a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
  - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

### 2.2 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Advance Products & Systems, Inc.
    - b. Calpico, Inc.
    - c. Metraflex Co.
    - d. Pipeline Seal and Insulator, Inc.
  - 2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
  - 3. Pressure Plates: Carbon steel. Include two for each sealing element.
  - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

#### 2.3 GROUT

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

# PART 3 - EXECUTION

#### 3.1 EXAMINATION

A. The Drawings do not indicate existing installations other than to identify modifications or extensions thereto. Visit the site and ascertain the existing conditions. Review construction details of the existing portion of the building during the site inspection. Include all work required to remove or modify portions of the existing installation in order to accommodate the new Work. Failure to comply with this will not be considered grounds for additional payment in

connection with removing or modifying any part of the existing installation or installing any new or temporary work.

# 3.2 TEMPORARY WORKING ACCESS

- A. Remove existing wire, conduit, equipment, fixtures, and other items as required to provide access for Work in existing facilities.
- B. Reinstall and refinish items removed, or otherwise damaged, to match existing adjacent conditions upon completion of the Work.

### 3.3 SALVAGE, DEMOLITION AND RELOCATION

- A. Modify, remove, salvage, or relocate materials, equipment and devices as indicated or required by the installation of new Work.
- B. Salvage and Demolition: Working jointly with the Owner's Representative, establish and mark salvage and demolition items before commencing work; report items scheduled for relocation, reinstallation or reuse, which are found to be in damaged condition; await further instructions from the Owner before commencing Work.
  - 1. Demolition material shall be removed from the site and disposed of in a legal manner.
  - 2. Salvaged equipment and devices shall be the property of the Owner, unless otherwise indicated. Store salvaged items in locations as directed by Owner.
  - 3. For devices and equipment marked for demolition, remove all conduit and wiring back to the point of origination, unless otherwise indicated.
  - 4. Where existing walls are demolished, remove all existing electrical devices, their associated conduit and wiring back to the point of origination.
  - 5. Where entire circuits are removed, turn the circuit breaker off and label as "spare".
  - 6. Maintain service to all "existing to remain" devices and equipment that may be interrupted during demolition.
  - 7. Upon completion of demolition, ensure that remaining devices that may have been interrupted during demolition are energized.
- C. Relocations: Make minor relocations necessitated by the conditions at the site or as directed by the Owner's Representative, without additional cost to the Owner.
  - 1. Remove items which are to be relocated in reverse order to original assembly or placement.
  - 2. Protect items until relocation is complete.

- 3. Clean, Repair and restore to good functional condition, equipment, materials and items scheduled for relocation. Provide new fittings and appurtenances required to complete the relocations and to restore to good operating order.
- D. Substitution of New materials for Relocation: New materials of similar design and quality may be substituted for materials and items indicated to be relocated upon approval of Owner and Architect. Comply with Division 01 for Substitution Procedures.

# 3.4 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. All materials, equipment and devices shall be installed in accordance with the recommendations of their manufacturer.
- B. Comply with NECA 1 Standard Practices for Good Workmanship in Electrical Construction, as published by the National Electrical Contractors Association.
- C. Use licensed technicians skilled in their respective trades for installation of the Work.
- D. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items, unless otherwise indicated.
- E. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- F. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a manner as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- G. Right of Way: Give to piping systems installed at a required slope.
- H. Access Panels: Provide wall and ceiling access panels for unrestricted access to all concealed electrical equipment items and devices installed behind furrings, chases or non-removable suspended ceilings. Access Panel materials and installation requirements are specified in Division 08 Section "Access Doors and Frames."
- I. Installation Inspections and Certifications
  - 1. Obtain timely inspections of the installation by Authorities Having Jurisdiction. Remedy any deficiencies to the satisfaction of the inspecting official.
  - 2. Upon final completion of the Work, obtain certificates of acceptance from the Authorities Having Jurisdiction. Deliver the certificates to the Owner.

# 3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

- B. Concrete Slabs and Walls: Install sleeves where cable or conduit penetrations occur. Install sleeves during erection of slabs and walls.
  - 1. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 2. Exception: Slab-on-grade construction shall not require sleeves or curbed formed openings when conduits or pipes that penetrate the slab-on-grade are installed and properly supported prior to the pouring of the slab.
- C. Masonry Walls: Install sleeves where cable or conduit penetrations occur. Install sleeves during erection of walls.
  - 1. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- F. Non Fire-Rated Assemblies: Install sleeves where cable penetrations occur. Install sleeves during erection of walls.
  - 1. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- G. Cut sleeves to length for mounting flush with both surfaces of walls.
- H. Extend sleeves installed in floors a minimum of 2 inches above finished floor level.
- I. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless otherwise indicated or.
- J. Seal space outside of sleeves with grout for penetrations of concrete and masonry.
  - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
  - 2. Apply approved joint compound for gypsum board assemblies where masonry or concrete wall is faced on interior side with gypsum board.
- K. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- L. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

- M. Roof-Penetration Sleeves: Seal penetration of individual conduits and cables with flashing units applied in coordination with roofing work. Provide flashing unit as specified in Division 07 Section "Sheet Metal Flashing and Trim".
- N. Aboveground, Exterior-Wall Penetrations: Seal penetrations using cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- O. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

### 3.6 OPTION TO RELOCATE DEVICES

A. The location of power, wall switches and other similar devices along with their associated connections may be relocated at the Owner's option, at no additional cost to the Owner, to a point within 10 feet of their present location provided the Contractor is notified prior to rough-in or installation.

### 3.7 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

# 3.8 UTILITIES

- A. The location and voltage of electrical lines included within the Work are indicated in the Contract Documents in accordance with information furnished by the Owner. Existing utility lines not indicated in Contract Documents but encountered during construction shall be protected, relocated or capped as directed by the Owner.
- B. Prior to excavation, examine the site and verify the location and elevation of all utilities and their relation to the Work. Identify and label all underground utilities occurring within the bounds of the area to be excavated. Contact the known utilities and engage a certified locator service to assist in this effort.
- C. Prior to excavation, contact the known utilities and inform them of excavation work plan. Proceed with excavation only after receiving approval from Utilities.
- D. All precautions shall be exercised to prevent damage to existing lines, but should work become necessary, it must be authorized prior to execution except in an emergency situation.
- E. Should damage result to any utility through the Contractor's negligence or failure to comply with the above directives, the Contractor shall bear the sole responsibility to correct such damage and shall be responsible for all expenses incurred in the expeditious repair or replacement of such damaged Utilities.

- F. Repair of damaged utilities shall be to a condition equal to or better than the adjacent undamaged portion of such utility and to the complete satisfaction of the Owner and respective Utility.
- 3.9 CONNECTIONS
  - A. Phase Rotation: Prior to installing any connections or energizing any equipment, perform Phase Rotation verification test at the following:
    - 1. Utility Transformers
    - 2. Engine Generators
    - 3. Motors
    - 4. Connections to existing electrical equipment.
  - B. Mechanical Controls: Provide 120VAC power connections as required to components of Mechanical Control system. Coordinated quantity of circuits, connection requirements and locations between trades and with provisions of Divisions 21, 22, and 23 sections.
  - C. HVAC Terminal Boxes: Where the Drawings indicate a 120VAC circuit in a general area and labeled for terminal boxes (VAV, etc.), the intent is for this circuit to be extended and connected to the terminal box in that general area. Coordinate connection requirements and locations between trades and with provisions of Division 23 Sections and Drawings.
  - D. Smoke Dampers: Where the Drawings indicate a 120VAC circuit in a general area and labeled for dampers, the intent is for this circuit to be extended and connected to the Smoke and Fire/Smoke dampers in that general area in coordination with the smoke control sequence. Coordinated connection requirements and locations between trades and with provisions of Division 23 Sections and Drawings.
  - E. Security and Access Control: Where the Drawings indicate a 120VAC circuit in a general area labeled for security or access control use, the intent is for this circuit to be extended and connected to the security or access control device in that general area in coordination with other trades. Coordinated connection requirements and locations between trades and with Owner's Security vendor prior to installation.
  - F. Motors and Motor Connections: Motors for driven equipment are specified in Divisions 21, 22, and 23. Provide connections as follows, unless otherwise indicated:
    - 1. Equipment provided with factory installed disconnecting means: Upon installation of motor and associated equipment, Provide the electrical installation in accordance with approved wiring diagrams and manufacturer's written instructions.
    - 2. Equipment furnished with factory disconnecting means: Upon installation of motor and associated equipment, Install factory furnished disconnecting means and provide the electrical installation in accordance with approved wiring diagrams and manufacturer's written instructions.

- 3. Equipment not furnished with factory installed disconnecting means: Provide disconnect switch required in accordance with NFPA 70 or as indicated on the Drawings. Provide the electrical installation in accordance with approved wiring diagrams and manufacturer's written instructions.
- G. Owner Furnished Equipment: Power Connections and Control wiring required for Owner Furnished Equipment may not be shown on the Drawings. This wiring shall be provided. Coordinated connection requirements and locations with Owner.
  - 1. Request all rough-in documentation required for proper installation of the electrical work in ample time to permit preparation of the installation drawings.

### 3.10 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."
- B. Apply putty pads to boxes located in fire-rated wall assemblies in which a horizontal distance of greater than 24" between boxes is not maintained. Putty pad materials and installation requirements are specified in Division 09 Section "Gypsum Board Assemblies."

# 3.11 SEALANT

A. Apply sealant to penetrations of all floor and wall assemblies to maintain pressure differentials required by AIA, CDC for all pressure sensitive rooms including: Isolation rooms, Protective Environment rooms, Operating rooms, C-section rooms, and Pharmacy including Chemo Prep, Sterile Prep and Ante rooms. Sealant materials and installation requirements are specified in Division 07 Section "Joint Sealants" and Division 09 Section "Gypsum Board Assemblies.

#### 3.12 FIELD QUALITY CONTROL

- A. Conduct tests as part of the Work of this Division. Include the services of qualified personnel as well as all equipment, apparatus, and services required.
- B. Conduct tests under conditions free from short circuits and from grounds.
- C. Insure insulation resistance prior to test is within the requirements of the latest edition of the NFPA 70.
- D. Prior to execution of testing, notify Architect of proposed test procedures and forms.
- E. Testing requirements are listed under individual sections of this Division. Sections requiring testing include, but are not limited to the following:
  - 1. Wire and cable insulation, in accordance with Division 26 Section "Low-Voltage Electrical Power Conductions and Cables."
  - 2. Grounding system continuity, in accordance with Division 26 Section "Grounding and Bonding for Electrical Systems."

- 3. Underground ducts and raceway integrity, in accordance with Division 26 Section "Underground Ducts and Raceways for Electrical Systems."
- 4. Monitoring operational and system continuity, in accordance with Division 26 Section "Electrical Power Monitoring and Control."
- 5. Lighting control devices, in accordance with Division 26 Section "Lighting Control Devices."
- 6. Lighting controls and system diagnostic, in accordance with Division 26 Section "Network Lighting Controls."
- 7. NETA tests for transformers, in accordance with Division 26 Section "Low-Voltage Transformers."
- 8. NETA tests and startup for switchgear, in accordance with Division 26 Section "Low-Voltage Switchgear."
- 9. NETA tests and startup for switchboards, in accordance with Division 26 Section "Switchboards."
- 10. NETA tests and startup for panelboards, in accordance with Division 26 Section "Panelboards."
- 11. Receptacle retention force, polarity, and ground resistance testing, in accordance with Division 26 Section "Wiring Devices."
- 12. NETA tests and startup for enclosed switches and circuit breakers, in accordance with Division 26 Section "Enclosed Switches and Circuit Breakers."
- 13. NETA tests and startup for enclosed controllers, in accordance with Division 26 Section "Enclosed Controllers."
- 14. NETA tests for surge protection devices, in accordance with Division 26 Section "SPD for Low-Voltage Electrical Power Circuits."
- 15. Emergency lighting tests, in accordance with Division 26 Section "LED Interior Lighting."
- 16. Illumination tests, in accordance with Division 26 Section "LED Exterior Lighting."
- 17. NETA thermographic survey on all electrical system equipment.

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### **SECTION 260519**

## LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following:
  - 1. Building wires and cables rated 600 V and less.
  - 2. Connectors, splices, and terminations rated 600 V and less.
  - 3. Sleeves and sleeve seals for cables.

#### 1.2 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.
- C. VFC: Variable frequency controller.

#### 1.3 ACTION SUBMITTALS

- A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section "Common Work Results for Electrical" for products specified under PART 2 - PRODUCTS.
- B. Product Data: For each type of product indicated. Provide data for conductors and cables including, but not be limited to, the following:
  - 1. Complete physical properties of the conductors and cables.
  - 2. Ampacity for use intended.
  - 3. Allowable stresses and requirements for installations, including bend radii, linear stress, and other pertinent data.
  - 4. Types of connectors for terminations.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Submit Coordination Drawings in accordance with Division 26 Section "Common Work Results for Electrical". Include the following:
  - 1. Feeder cable routing plans, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
    - a. Structural members in the paths of conduit groups with common supports.

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- b. HVAC, plumbing items, and architectural features in the paths of conduit groups. Denote where systems share common supports.
- B. Qualification Data: For testing agency.
- C. Field quality-control test reports.

### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For conductors and cables, to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation And Maintenance Data," include the following:
  - 1. Manufacturer's routine maintenance requirements for cables, terminations and all installed components.

### 1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: For independent agency as defined in Division 26 Section "Common Work Results for Electrical".

#### 1.7 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

# PART 2 - PRODUCTS

#### 2.1 CONDUCTORS AND CABLES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering Copper products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Alcan Products Corporation; Alcan Cable Division.
  - 2. Alpha Wire.
  - 3. Belden Inc.
  - 4. Encore Wire Corporation.
  - 5. General Cable Technologies Corporation.
  - 6. Southwire Incorporated.
- B. Manufacturers: Subject to compliance with requirements, provide Aluminum products by one of the following:
  - 1. Stabiloy; General Cable Technologies Corporation.

- 2. Southwire Incorporated.
- C. Aluminum and Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.
- D. XHHW Conductors: Comply with NEMA WC 70.
- E. Aluminum Conductors: XHHW-2
  - 1. Comply with NEMA WC 70.
  - 2. AA-8000 series electrical grade aluminum alloy conductor material in compliance with NFPA 70, Chapter 3.
  - 3. Compact stranded conductors.
- F. Shielded Variable Frequency Drive Cable: Shielded Conductor and signal cable with symmetric bare grounds and overall shield to block EMI and RFI interference.
  - 1. Conductor Material: stranded tinned copper
  - 2. Shield: Foil tape and tinned copper braid shield
  - 3. Comply with 2000V UL 1277 Type TC-ER per NEC Article 336 "Power and Control Tray Cable: Type TC"
  - 4. Rated for  $90^{\circ}$ C wet/dry
  - 5. Suitable for Class I & II; Division 2 hazardous locations
  - 6. Comply with UL 1685 vertical tray flame test
  - 7. Comply with IEEE 1202 vertical tray flame test at 70,000 BTU/hour
  - 8. Comply with CSA FT4
  - 9. Comply with Oil & Sunlight resistant
  - 10. RoHS compliant and CE approved.
- G. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Types THHN-THWN, XHHW, XHHW-2 and SO, as indicated.
- H. Multiconductor Cables: Comply with NEMA WC 70/IECA S-95-658; Exterior sheath color coded to differentiate cable voltages and quantity of phase conductors.
  - 1. Health Care Facilities armored cable, Type AC-HCF; Comply with UL 4 and UL 1479; with green grounding conductor(s) in addition to Armor/Bond Wire ground combination; with exterior sheath colored green.

- 2. Health Care Facilities Metal-clad cable, Type MC<sup>AP</sup>-HCF; Comply with UL 1569 and UL 1063; with green grounding conductor(s) in addition to full size aluminum ground wire/sheath combination that is listed for sheath to act as second ground path; with exterior sheath colored green.
- 3. Mineral-insulated, metal-sheathed cable, Type MI; with green grounding conductor(s). Listed for use in Environmental Air space according to NPFA 70 Article 300.
- 4. Type SO; with green grounding conductor(s).

# 2.2 CONNECTORS AND SPLICES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. AFC Cable Systems, Inc.
  - 2. Gardner Bender.
  - 3. Hubbell Power Systems, Inc.
  - 4. Ideal Industries, Inc.
  - 5. Ilsco; a branch of Bardes Corporation.
  - 6. NSi Industries LLC.
  - 7. O-Z/Gedney; a brand of the EGS Electrical Group.
  - 8. 3M; Electrical Markets Division.
  - 9. Tyco Electronics.
  - 10. WAGO Corporation.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

# 2.3 MISCELLANEOUS PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
  - 1. Minimum Width: 3/16 inch.
  - 2. Tensile Strength: 50 lb, minimum.
  - 3. Temperature Range: Minus 40 to plus 185 deg F.
  - 4. Color: Black, except where used for color-coding. Refer to Division 26 Section "Identification for Electrical Systems" for color-coding requirements.

### 2.4 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

# PART 3 - EXECUTION

# 3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper for all feeders. aluminum for feeders where indicated on Drawings. Solid or stranded for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid or stranded for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- C. Provide conductors with minimum temperature ratings of 75 degrees C. For high temperature applications, provide conductors with temperature ratings in accordance with the NFPA 70 for the ambient condition.
- 3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS
  - A. Service Entrance:
    - 1. Copper: Type THHN-THWN, single conductors in raceway
    - 2. Aluminum: Type XHHW-2, single conductors in raceway, where indicated on Drawings.
  - B. Exposed Feeders:
    - 1. Copper: Type THHN-THWN, single conductors in raceway.
    - 2. Aluminum: Type XHHW-2, single conductors in raceway, where indicated on Drawings.
  - C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces:
    - 1. Copper: Type THHN-THWN, single conductors in raceway.
    - 2. Aluminum: Type XHHW-2, single conductors in raceway, where indicated on Drawings.
  - D. Feeders below Slabs-on-Grade, and Underground:
    - 1. Copper: Type THHN-THWN, single conductors in raceway.
    - 2. Aluminum: Type XHHW-2, single conductors in raceway, where indicated on Drawings.
    - 3. Aluminum: Type XHHW-2, single conductors in raceway, where indicated on Drawings.

- E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway and Type AC-HCF and Type MCAP-HCF in limited locations where indicated.
  - 1. Type AC-HCF and Type MC<sup>AP</sup>-HCF are acceptable for the following applications.
    - a. Install cables for lighting fixture whips and for branch circuits concealed in walls and partitions only.
      - 1) Do not install the cable in the vertical web of metal studs.
      - 2) Route cable horizontally using pre-fabricated openings in web of metal stud.
      - 3) Use only single-circuit cable (i.e. two wire plus ground). For devices in the same wall connected to different circuits, install separate single circuit cable for each circuit.
      - 4) Locate junction box and convert to single conductors in rigid raceway within the same room as where the cable enters/exits the wall.
        - a) For branch power circuits limit length of AC-HCF and MC<sup>AP</sup>-HCF to 30' from the junction box to the wiring device located in the wall. If the circuit continues outside the wall, the circuit must immediately transition to conduit.
        - b) For branch lighting circuits limit length of AC-HCF and MC<sup>AP</sup>-HCF to 30' from the junction box to the first fixture and from that point only those fixtures above the enclosed space/room shall be served by the HCF circuit.
  - 2. Type AC-HCF and Type MC<sup>AP</sup>-HCF are not acceptable for the following applications; instead provide single conductors in rigid raceway.
    - a. Homeruns to Panelboard.
    - b. Branch circuits serving Essential Electrical System (Emergency & Standby) loads; including Life Safety branch, Critical branch and equipment emergency system.
    - c. Branch circuits serving HVAC, elevator/escalator, medical and kitchen equipment loads.
    - d. Within mechanical, electrical or telecommunication equipment rooms.
    - e. Exposed Branch Circuits within areas that do not have a ceiling (i.e. open to structure).
    - f. Wet Locations.

- G. Branch Circuits below Slabs-on-Grade, and Underground in limited locations where indicated: Type THHN-THWN, single conductors in raceway.
- H. Connections to Luminaires on Normal System: Armored Cable, Type AC-HCF, maximum of 144 inches (3660 mm).
- I. Connections to Luminaires on Essential/Emergency System Armored Cable, Type AC-HCF, maximum of 144 inches (3660 mm).
- J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainlesssteel, wire-mesh, strain relief device at terminations to suit application.
- K. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- L. Class 2 and 3 Control Circuits; Concealed in Ceilings, Walls or Partitions: Power-limited cable or Type THHN-THWN, in raceway.
- M. Class 2 and 3 Control Circuits; Exposed: Type THHN-THWN, in raceway.

### 3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Run feeders in continuous lengths, without joints or splices. Where continuous runs are impractical; obtain Engineer's approval for splice locations and application.
- B. Make joints in branch circuits only where circuits divide.
- C. Do not use gutters of panelboards as raceways, junction boxes, or pull boxes for conductors not terminating in said panelboards.
- D. Run conduits for emergency power conductors separate from all other wiring.
- E. Make splices and terminations in cables with kits and instructions provided by the kit manufacturer. Each splice shall equal the integrity of the cable electrically and environmentally.
- F. Bundling Conductors: Bundle conductors in switchboards, panelboards, cabinets, and the like, using nylon ties made for the purpose. Bundle conductors larger than No. 10 in individual circuits. Smaller conductors may be bundled in larger groups.
- G. Install all conductors in raceways, unless otherwise indicated.
- H. Sizes:
  - 1. Provide conductors no smaller than No. 12 AWG, except for signal or control circuits.
  - 2. Provide No. 10 AWG conductors for home runs on 120-volt, 20-ampere branch circuits, where the conductor length exceeds 100 lineal feet from panelboard to the first device.
  - 3. Provide No. 10 AWG conductors for home runs on 277-volt, 20-ampere branch circuits, where the conductor length exceeds 200 lineal feet from panelboard to the first device.

- 4. Provide neutral conductors of the same size as the phase conductor(s) for individual branch circuit homeruns.
- 5. Run dedicated neutral conductor with each branch circuit. Sharing of neutral conductors in multi-circuit homeruns is not acceptable.
  - a. Sharing of neutrals would necessitate the use of multiple-pole or tied branch circuit breakers to allow simultaneous disconnecting of current caring conductors in order to comply with NFPA 70 requirements and therefore is unacceptable.
- 6. Grouping of Multi-Circuit homeruns: grouping of multiple circuits into shared conduit homeruns is acceptable where they comply with the quantities and sizes listed in Table "A" below and where homeruns meet the following conditions:
  - a. Where conductors are THWN/THHN installed in dry location.
  - b. Where raceways are installed in ambient conditions less than 30-Deg C (86-Deg F).
  - c. Consider neutral conductors as a current carrying conductor in branch circuits which serve receptacles or electronic ballasted luminaries.

ТΑ	BI	E	А	
111			11	

Number of Current Carrying	Conductor Size for 20Ampere	Conduit Size based
Conductors in single raceway	Single Pole Circuit	on EMT
2 to 3	#12 AWG (THHN 75-Deg) or	3/4" EMT
	#12 AWG (THHN 90-Deg)	
4 to 6	#12 AWG (THHN 75-Deg) or	3/4" EMT
	#12 AWG (THHN 90-Deg)	
7 to 9	#10 AWG (THHN 75-Deg) or	1" EMT
	#12 AWG (THHN 90-Deg)	3/4" EMT
10 to 12	#10 AWG (THHN 90-Deg)	1.25" EMT

Notes:

1. Conductor and conduit sizes in table above are based on total conductor lengths under 100 lineal feet for 120-volt (200 lineal feet for 277-volt) from panelboard to the first device, 20-ampere branch circuits. Increase conductor and conduit size in accordance with NFPA 70 for longer lengths.

- I. Terminations of multiple branch circuit conductors on a single circuit breaker is not acceptable.
- J. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- K. Complete raceway installation between conductor and cable termination points according to Division 26 Section "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- L. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours.

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- M. Provide Shielded Variable Frequency Drive Cable between VFDs and equipment being served as followed:
  - 1. Cable distance exceeds 50'.
  - 2. Multiple circuits in a single conduit.
- N. For VFDs located remote from the equipment it is serving, provide auxiliary connection between disconnect switch and VFD.
- O. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- P. Feeders and Branch circuits concealed in concrete are prohibited.

### 3.4 WIRE PULLING

- A. Pull no conductors into conduits until all Work of a nature which may cause injury to conductors is completed.
- B. Follow manufacturers' recommendations for regulating temperature conditions of conductors prior to installation.
- C. Exercise care in handling and installing cables to avoid damage. Carefully form cables in equipment pull boxes. Form bends in cables larger than the minimum radii shown in the cable manufacturer's published data for minimum bends such that bends will not reduce the cable life.
- D. Provide suitable installation equipment to prevent abrasion and cutting of conductors by raceways during the pulling of conductors. Use ropes of polyethylene, nylon or other suitable non-metallic material to pull in feeders. Metallic ropes are prohibited.
- E. Attach pulling lines to conductors by means of insulated woven basket grips or by pulling eyes attached directly to conductors. Do not use rope hitches, or bare steel basket grips. All conductors to be installed in a single conduit shall be pulled in simultaneously.
- F. Before any wire is pulled into any conduit, thoroughly swab the conduit to remove all foreign material and to permit the wire itself to be pulled into a clean, dry conduit.
- G. Use manufacturer-approved pulling compound or lubricant where necessary, of non-conducting type. Compounds used must not deteriorate the conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- H. Do not use cable pulling lubricants on conductors of ungrounded circuits which are electrically monitored by ground detector system, since such lubricant may increase the capacities to ground of these conductors.

# 3.5 CONNECTIONS

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

- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
  - 1. Use oxide inhibitor in each splice and tap conductor.
- C. Wiring at Outlets: Install conductor at each device, with at least 6 inches (150 mm) of slack.
- D. Wiring at lighting control locations: Install a neutral conductor at each switch location controlling line-to-neutral lighting loads.
- E. Connectors: Make splices and connections in conductors using approved connectors.
  - 1. Provide lugs and connectors of proper size to match conductor size.
  - 2. Stranded Conductors: Solder-less, bolted pressure or compression connectors.
  - 3. Solid Conductors: Bolted pressure or spring connectors.
  - 4. Motor Lead Pigtails: Crimp lugs with through-bolt fasteners between lugs. Furnish proper sized dies and tools to apply connectors.
  - 5. Lighting Fixture Taps: Electrical spring connectors as specified for solid conductors.
  - 6. Ground Connections: Ground connection materials and installation requirements are specified in Division 26 Section "Grounding and Bonding for Electrical Systems."
- F. Provide temperature ratings of connectors and splices to match wire rating.

#### 3.6 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

#### 3.7 SLEEVE AND SLEEVE SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Apply Sleeve and Sleeve Seal where raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies. Sleeve and Sleeve Seal materials and installation requirements are specified in Division 26 Section "Common Work Results for Electrical."

#### 3.8 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

### 3.9 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
  - 1. Test insulation resistance for each feeder, and branch circuit.
  - 2. Test continuity of each circuit.
- B. Testing Agency: Engage a qualified independent testing and inspecting agency as defined in Division 26 Section "Common Work Results for Electrical" to perform the following field tests and inspections and prepare certified test reports:
  - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance conductors, and conductors of No. 2 AWG and larger for compliance with requirements.
  - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts dc for one minute.
- D. Perform continuity test to insure correct cable connection.
- E. Test Values
  - 1. Bolt-torque levels shall be in accordance with Table 1.1 thru Table 1.4, unless otherwise specified by the manufacturer.

Tuble III Don Forque for Dus Connection using Cuannum of Zine Fluten fieure steel							
Grade	SAE 1 & 2	SAE 5	SAE 7	SAE 8			
Minimum Tensile (P.S.I.)	64K	105K	133K	150K			
Bolt Diameter (Inches)	Torque (Foot Pounds)						
1/4	4.0	5.6	8.0	8.4			
5/16	7.2	11.2	15.2	17.6			
3/8	12.0	20.0	27.2	29.6			
7/16	19.2	32.0	44.0	48.0			
1/2	29.6	48.0	68.0	73.6			
9/16	42.4	70.4	96.0	105.6			
5/8	59.2	96.0	133.6	144.0			
3/4	96.0	160.0	224.0	236.8			
7/8	152.0	241.6	352.0	378.4			
1	225.6	372.8	528.0	571.2			

Table 1.1 - Bolt Torque for Bus Connection using Cadmium or Zinc Plated Heat-Treated Steel

Table 1.2 - Bolt Torque for Bus Connection using Silicon Bronze Fasteners<sup>1</sup>

	Non- Lubricated	Lubricated	
Bolt Diameter (Inches)	Torque (Foot Pounds)		
5/16	15.0	10.0	

3/8	20.0	14.0
1/2	40.0	25.0
5/8	55.0	40.0
3/4	70.0	60.0

<sup>1</sup> Bronze alloy bolts with minimum tensile strength of 70,000 pounds per square inch.

	Lubricated
Bolt Diameter (Inches)	Torque (Foot Pounds)
5/16	8.0
3/8	11.2
1/2	20.0
5/8	32.0
3/4	48.0

<sup>2</sup> Aluminum alloy bolts with minimum tensile strength of 55,000 pounds per square inch.

	Uncoated				
Bolt Diameter (Inches)	Torque (Foot Pounds)				
5/16	14.0				
3/8	25.0				
1/2	45.0				
5/8	60.0				
3/4	90.0				

Table 1.4 -	Bolt Tor	ue for Bus	Connection	using Stai	nless Steel	Fasteners <sup>3</sup>
1 4010 111	2010 1010	ac for Dab	connection	abiling brui	mess steel	I abteners

<sup>3</sup> Bolts, cap screws, nuts, flat washers, locknuts: 18-8 alloy. Belleville washers: 302 alloy.

- a. Minimum insulation-resistance values shall be not less than 50 megohms.
- b. Investigate deviations between adjacent phases.
- 2. Infrared Scanning: Perform Thermographic Survey in accordance with NETA ATS, Section 9.0.
  - a. Initial Infrared Scanning: Within 60 Days after Substantial Completion, perform an infrared scan of each termination of or splice in cables and conductors No. 3 AWG and larger. Open or remove doors and covers so connections are accessible to portable scanner.
  - b. Instruments, Equipment:
    - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- F. Cables will be considered defective if they do not pass tests and inspections.

- G. Correct Deficiencies, Retest and Report:
  - 1. Correct unsatisfactory conditions, and retest to demonstrate compliance; replace conductors, units, and devices as required to bring system into compliance.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  - 3. Prepare a written report, certified by testing agency, to record the following:
    - a. Procedures used.
    - b. Results that comply with requirements, identifying conductor, units, and devices checked.
    - c. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
    - d. Observations and test results after remedial action.

# END OF SECTION

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### **SECTION 260526**

### **GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

## PART 1 - GENERAL

### 1.1 SUMMARY

- A. NFPA 70 and IEEE C2 include basic grounding requirements for electrical safety. This Section supplements the minimum safety requirements of the Code with requirements for additional grounding and with optional grounding methods and materials for both power and electronic systems.
- B. This Section includes methods and materials for grounding and bonding systems and equipment, plus the following special applications:
  - 1. Common ground bonding with lightning protection system.
- C. Related Sections include the following:
  - 1. Division 26 Section "Lightning Protection for Structures" for common ground bonding with lightning protection system.
  - 2. Division 27 Section "Grounding and Bonding for Communications Systems" for common ground bonding of Communications Systems including grounding bus.

### 1.2 ACTION SUBMITTALS

- A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section "Common Work Results for Electrical" for products specified under PART 2 - PRODUCTS.
- B. Product Data: For each type of product indicated.

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
  - 1. Test wells.
  - 2. Ground rods.
  - 3. Ground rings.
  - 4. Grounding arrangements and connections for separately derived systems.
  - 5. Grounding for sensitive electronic equipment.
- B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control test reports.

### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding, to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation And Maintenance Data," include the following:
  - 1. Manufacturer's routine maintenance requirements for cables, terminations and all installed components.
  - 2. Instructions for periodic testing and inspection of grounding features at grounding connections for separately derived systems and, test wells and ground rings based on NETA MTS.
    - a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
    - b. Include recommended testing intervals.

### 1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: For independent agency as defined in Division 26 Section "Common Work Results for Electrical".
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 467 for grounding and bonding materials and equipment.
- D. Comply with NFPA 70.
- E. Comply with NFPA 99.
- F. Comply with IEEE C2.
- G. Comply with ANSI-J-STD-607-A.

# PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Burndy; Part of Hubbell Electrical Systems.
  - 2. Dossert; AFL Telecommunications LLC.
  - 3. ERICO International Corporation.

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- 4. Fushi Copperweld Inc.
- 5. Galvan Industries, Inc.; Electrical Products Division, LLC.
- 6. Harger Lightning and Grounding.
- 7. ILSCO.
- 8. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
- 9. Robbins Lightning, Inc.
- 10. Siemens Power Transmission & Distribution, Inc.

#### 2.2 CONDUCTORS

- A. Insulated Conductors: Tinned-Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
  - 1. Solid Conductors: ASTM B 3.
  - 2. Stranded Conductors: ASTM B 8.
  - 3. Tinned Conductors: ASTM B 33.
  - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
  - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
  - 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
  - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
  - 8. Main Bonding Jumper: stranded copper conductors sized as indicated on Drawings.
  - 9. Grounding Electrode Conductor: stranded copper conductors sized as indicated on Drawings.
  - 10. Common Grounding Electrode Conductor: stranded copper conductors sized as indicated on Drawings.

#### 2.3 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, long barrel with at least two bolts.
  - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

## 2.4 GROUNDING BUSBARS

- A. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V, unless otherwise indicated. Length as indicated:
  - 1. Main Electrical Room ground bus length: 20 inches (508 mm).
  - 2. Branch Electrical Room ground bus length: 20 inches (508 mm).

## 2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 5/8 inch (16 mm) diameter by 120 inches (3000 mm, unless otherwise indicated.

## PART 3 - EXECUTION

#### 3.1 APPLICATIONS

- A. Conductors: Insulated solid or stranded for No. 10 AWG and smaller, insulated stranded for No. 8 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 3/0 AWG minimum.
  - 1. Bury at least 30 inches below grade.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
  - 1. Install bus horizontally, on insulated spacers 2 inch minimum, from wall 12 inches above finished floor or 6 feet (1.8 m) above transformer, unless otherwise indicated.
  - 2. Clean and apply anti-oxidant to the contact area prior to conductor connection.

- E. Conductor Terminations and Connections:
  - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
  - 2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
  - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
  - 4. Connections to Structural Steel: Welded connectors.
- 3.2 GROUNDING AT THE SERVICE
  - A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

## 3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Generator: Install grounding electrode(s) at the generator location as indicated on the Drawings. The electrode shall be connected to the frame of the generator.
- B. Dry-Type Transformers: Install an insulated grounding conductor from the common point of connection of the transformer secondary neutral point and the transformer enclosure to the following:
  - 1. The nearest grounding electrode per NFPA 70, including but not limited to building steel where available.
  - 2. The grounding bus of the common electrode grounding system, located in the electrical equipment room.

## 3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

## 3.5 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
  - 1. Bond to each device, box, and luminaire, unless otherwise indicated.

- 2. Conduction insulation of the same rating as the phase conductors, for all feeders and branch circuits. Install the grounding conductors in the raceway with related phase and neutral conductors.
- 3. Where parallel conductors in separate raceways occur, provide a grounding conductor in each raceway that meets requirements of NFPA 70.
- B. Enclosures: Install an insulated grounding conductor from grounding bushings to the frame of the enclosure, ground bus, and equipment grounding strap where each occurs. Install grounding bushings on all raceways connecting electrical enclosures constructed of separate enclosure panels, which are not integrally welded together.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to ductmounted electrical devices operating at 120 V and more, including but not limited to air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway. Terminate at grounding conductor terminal on isolated ground bus of equipment of the applicable derived system or service, unless otherwise indicated.

## 3.6 INSTALLATION

- A. Provide permanent service neutral and equipment grounding in accordance with NFPA 70 and subject to the following additional requirements.
- B. Comply with mounting and support requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- C. Connect the service neutral and equipment ground to a common point within the metallic enclosure containing the main service disconnecting means. Equipment grounds and the identified neutral of the wiring system shall not be interconnected beyond this point in the interior wiring system. From the common point of connection of the service neutral and the equipment ground, run in non-magnetic conduit a grounding electrode conductor without joint or splice to the grounding electrode system and connect it with an approved bolted pressure clamp.
- D. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

- E. Ground Rods: Drive rods until tops are 12 inches below finished floor or final grade, unless otherwise indicated.
  - 1. Interconnect ground rods with grounding electrode conductor a minimum of 30-inches below grade unless otherwise indicated. Make connections without exposing steel or damaging coating, if any.
  - 2. For grounding electrode system, install at least three rods spaced at least 6 feet (1.8 m) from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- F. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.
  - 1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- G. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
  - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
  - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
  - 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
  - 4. Where expansion joints or telescoping joints occur, provide bonding jumpers.
- H. Grounding and Bonding for Piping:
  - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes within 5' of point of entrance, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
  - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
  - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

- I. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.
- J. Concrete-Encased Grounding Electrode: Fabricate according to NFPA 70, using a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG or a minimum of 20 feet exothermic weld to rebar.
  - 1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.
  - 2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

## 3.7 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components as specified in Division 26 Section "Identification for Electrical Systems."

## 3.8 CONNECTIONS

- A. Ground Connections: Provide ground clamps or connectors of a suitable type for ground applications.
- B. Ground Bars: Irreversible exothermic welded connector.

## 3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent testing and inspecting agency as defined in Division 26 Section "Common Work Results for Electrical" to perform the following field tests and inspections and prepare certified test reports:
  - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
  - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
  - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
    - a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    - b. Perform tests by fall-of-potential method according to IEEE 81.

- 4. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- B. Tests for patient-care areas: In addition to the test listed above, perform additional field tests and inspections for patient care areas. Patient care areas are defined by the LAHJ.
  - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements. Perform the following tests:
    - a. Impedance: Measurement shall be made between the reference point and the grounding contact of all receptacles in the patient care room. The maximum limit allowed is 0.1 ohms.
    - b. Voltage: Measurement shall be made under no-fault conditions between a reference point and all exposed fixed electrical equipment with conductive surfaces in the patent care vicinity, including but not limited to: overbed wall-mounted fixtures, ceiling mounted exam lights, sensor faucets, etc. The maximum limit allowed is 20mV.
  - 2. Prepare certified test reports in compliance with NFPA 99 and submit reports in conjunction with field quality control reports required in Division 26 Section "Wiring Devices". Utilize the Patient Care Area Electrical Testing Form in the Appendix of this section for each patient care area.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.
  - 1. Report measured ground resistances that exceed the following values:
    - a. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
    - b. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
    - c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
    - d. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
    - e. Substations and Pad-Mounted Equipment: 5 ohms.
    - f. Manhole Grounds: 10 ohms.

- F. Correct Deficiencies, Retest and Report:
  - 1. Correct unsatisfactory conditions, and retest to demonstrate compliance; replace conductors, units, and rods as required to bring system into compliance.
  - 2. Prepare a written report, certified by testing agency, to record the following:
    - a. Procedures used.
    - b. Results that comply with requirements, identifying components checked.
    - c. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
    - d. Observations and test results after remedial action.

# **END OF SECTION**

## APPENDIX

# PATIENT CARE AREA ELECTRICAL SYSTEM INSPECTION / TESTING FORM

DATE:

ROOM NO:

LOCATION:

INSPECTED BY:

INSTRUMENTATION:

Room Rcpt. No.	Mechanical Condition	Wiring / Polarity	Contact Tension		Voltage		CECI Tria	Ground	Ground Re-	
			Н	N	0	H-N	N-O	GFCI Inp	(millivolts)	sistance (Ohms)

REMARKS:

**REFERENCE POINTS:** 

(mark on sketch)

ROOM LAYOUT SKETCH

**END OF APPENDIX** 

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## **SECTION 260553**

## **IDENTIFICATION FOR ELECTRICAL SYSTEMS**

## **PART 1 - GENERAL**

#### 1.1 **SUMMARY**

- A. This Section includes the following:
  - 1. Identification for raceways.
  - 2. Identification for conductors and multi-conductor cables.
  - 3. Underground-line warning tape.
  - 4. Warning labels and signs.
  - 5. Instruction signs.
  - 6. Equipment identification labels.
  - 7. Miscellaneous identification products.
- B. Related Sections include the following:
  - Division 26 Section "Wiring Devices" for engraved wall plates and wiring device 1. identification requirements.

#### 1.2 ACTION SUBMITTALS

- Submit product data and shop drawings in accordance with Division 01 and Division 26 Section A. "Common Work Results for Electrical" for products specified under PART 2 - PRODUCTS.
- Β. Product Data: For each electrical identification product indicated.
- C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.
- D. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

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- 1.3 QUALITY ASSURANCE
  - Comply with ANSI A13.1. A.
  - B. Comply with NFPA 70.
  - C. Comply with 29 CFR 1910.144 and CFR 1910.145.

- D. Comply with ANSI Z535.4 for safety signs and labels.
- Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks E. used by label printers, shall comply with UL 969.

#### COORDINATION 1.4

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

## **PART 2 - PRODUCTS**

#### POWER AND CONTROL RACEWAY IDENTIFICATION MATERIALS 2.1

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Color for Raceways Carrying Circuit at 600V or Less:
  - 1. Black letters on an orange field.
  - 2. Legend: Indicate voltage and system or service type, if applicable.
- C. Colors for Raceways Carrying Circuits at More Than 600 V:
  - 1. Black letters on an orange field.
  - 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING."
- Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600V or Less: Preprinted, D. flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

#### 2.2 MULTI-CONDUCTOR CABLE IDENTIFICATION MATERIALS

Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of A. color field for each cable size.

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- Colors for Cables Carrying Circuits at 600 V and Less: B.
  - 1. Black letters on an orange field.

- 2. Legend: Indicate voltage and system or service type.
- C. Colors for Cables Carrying Circuits at More Than 600 V:
  - 1. Black letters on an orange field.
  - 2. Legend: "DANGER HIGH VOLTAGE WIRING."
- D. Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.
- E. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

#### 2.3 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- C. Brass or Stainless Steel Wraparound Marker Labels: Cut from 0.014-inch-thick, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.
- D. Metal Tags: Brass or Stainless Steel, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking nylon tie fastener.
- 2.4 UNDERGROUND-LINE WARNING TAPE
  - A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
    - 1. Not less than 6 inches wide by 4 mils thick.
    - 2. Compounded for permanent direct-burial service.
    - 3. Embedded continuous metallic strip or core.
    - 4. Printed legend shall indicate type of underground line.

#### 2.5 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
- C. Baked-Enamel Warning Signs:

- 1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for interior application.
- 2. 1/4-inch grommets in corners for mounting.
- 3. Nominal size, 7 by 10 inches.
- D. Metal-Backed, Butyrate Warning Signs:
  - 1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396inch galvanized-steel backing; and with colors, legend, and size required for exterior application.
  - 2. 1/4-inch grommets in corners for mounting.
  - 3. Nominal size, 10 by 14 inches.
- E. Warning label and sign shall include, but are not limited to, the following legends:
  - 1. Multiple Power Source Warning: "DANGER ELECTRICAL SHOCK HAZARD EQUIPMENT HAS MULTIPLE POWER SOURCES."
  - 2. Workspace Clearance Warning: "WARNING OSHA REGULATION AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR ## INCHES." Verify work space required for specific project conditions with NFPA 70 and replace "##" in previous sentence with appropriate distance.
  - 3. Arc Flash Warning and Instructions: "WARNING ARC FLASH AND SHOCK HAZARD. WEAR APPROPRIATE PPE. Determine appropriate protective clothing and personal protective equipment (PPE) for the task from NFPA 70E."
  - 4. Provide detailed labeling in accordance with requirements listed in Division 26 Section "Overcurrent Protective Device Coordination Study".

# 2.6 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.
  - 1. Engraved legend with black letters on white face.
  - 2. Punched or drilled for mechanical fasteners.
  - 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
- 2.7 BUSSING DIAGRAM NAMEPLATE
  - A. Preprinted engraved, laminated acrylic or melamine plastics sign. Nominal size, 12 by 12 inches1/8 inch (3.2 mm) thick. Engraved legend with black letters on white face. Image on sign

depicting equipment components in single-line diagram format, using symbols and letter designations consistent with final one-line diagram. Produce a concise visual presentation of principal equipment components and connections.

## 2.8 EQUIPMENT IDENTIFICATION LABELS

- A. Engraved, Laminated Acrylic or Melamine Label: Adhesive, Punched, or drilled for screw mounting. Minimum letter height shall be 3/8 inch. Lettering and Background colors as indicated below:
  - 1. Power Circuits:
    - a. Normal: Match existing Verify with Owner
    - b. Emergency Legally Required Standby or Essential Electrical System prior to ATS: Match existing - Verify with Owner
    - c. Emergency Optional Standby: Match existing Verify with Owner
    - d. Life Safety Branch: Match existing Verify with Owner
    - e. Critical Branch: Match existing Verify with Owner
    - f. Equipment Emergency System: Match existing Verify with Owner
    - g. Non-Essential Emergency System: Match existing Verify with Owner
  - 2. Fire Alarm System: White lettering on Red background.
  - 3. Fire-Suppression Supervisory and Control System: Match existing Verify with Owner
  - 4. Combined Fire Alarm and Security System: Match existing Verify with Owner
  - 5. Security System: Match existing Verify with Owner
  - 6. Mechanical and Electrical Supervisory System: Match existing Verify with Owner
  - 7. Telecommunication System: Match existing Verify with Owner
  - 8. Control Wiring: Match existing Verify with Owner
  - 9. Nurse Call: Match existing Verify with Owner
  - 10. Public Address / Intercom: Match existing Verify with Owner
  - 11. CATV / MATV: Match existing Verify with Owner
  - 12. Clock: Match existing Verify with Owner

### 2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Conductor Color-Coding Key: Engraved, Laminated Acrylic, Melamine Label, or Decal-Style Label: Adhesive, Punched, or drilled for screw mounting. Minimum letter height shall be 3/8 inch. Key to describe the conductor color coding scheme used in building in accordance with NFPA 70.

## 2.10 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
  - 1. Minimum Width: 3/16 inch.
  - 2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
  - 3. Temperature Range: Minus 40 to plus 185 deg F.
  - 4. Color: Black except where used for color-coding.
- B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
  - 1. Minimum Width: 3/16 inch.
  - 2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
  - 3. Temperature Range: Minus 40 to plus 185 deg F.
  - 4. Color: Black.
- C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
  - 1. Minimum Width: 3/16 inch.
  - 2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.
  - 3. UL 94 Flame Rating: 94V-0.
  - 4. Temperature Range: Minus 50 to plus 284 deg F.
  - 5. Color: Black.
- D. Paint: Paint materials and application requirements are specified in Division 09 painting Sections.
  - 1. Exterior Ferrous Metal:
    - a. Semigloss Alkyd-Enamel Finish: One finish coat(s) over a primer.
      - 1) Primer: Exterior ferrous-metal primer.

- 2) Finish Coats: Exterior semigloss alkyd enamel.
- 2. Exterior Zinc-Coated Metal (except Raceways):
  - a. Semigloss Alkyd-Enamel Finish: One finish coat(s) over a primer.
    - 1) Primer: Exterior zinc-coated metal primer.
    - 2) Finish Coats: Exterior semigloss alkyd enamel.
- 3. Interior Ferrous Metal:
  - a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a primer.
    - 1) Primer: Interior ferrous-metal primer.
    - 2) Finish Coats: Interior semigloss acrylic enamel.
- 4. Interior Zinc-Coated Metal (except Raceways):
  - a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a primer.
    - 1) Primer: Interior zinc-coated metal primer.
    - 2) Finish Coats: Interior semigloss acrylic enamel.
- E. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- F. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape with adhesive appropriate to the location and substrate.

- G. Conductor Color-Coding Key: Install Instructional Label denoting the conductor color-coding scheme on all panelboards, distribution boards, switchboards, switchgear, motor-control center and similar equipment.
- H. Conductor Color-Coding for Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
  - 1. Color shall be factory applied to conductors or for sizes larger than No. 8 AWG, if authorities having jurisdiction permit, field applied.
  - 2. Colors for Grounding Conductors:
    - a. Equipment Grounding Conductor: Green.
    - b. Isolated Equipment Grounding Conductor: Green with Yellow Stripe.
  - 3. Colors for 208/120-V Wye Systems:
    - a. Phase A: Black.
    - b. Phase B: Red.
    - c. Phase C: Blue.
    - d. Grounded Conductor (Neutral): White
  - 4. Colors for 208/120-V and 240/120-V Delta Systems:
    - a. Phase A: Black.
    - b. Phase B (High Leg): Orange.
    - c. Phase C: Blue.
    - d. Grounded Conductor (Neutral): White
  - 5. Colors for 480/277-V Wye Systems:
    - a. Phase A: Brown.
    - b. Phase B: Orange
    - c. Phase C: Yellow.
    - d. Grounded Conductor (Neutral): Gray
  - 6. Colors for 480/277-V Delta Systems:
    - a. Phase A: Brown.
    - b. Phase B (High Leg): Orange.

- c. Phase C: Yellow.
- d. Grounded Conductor (Neutral): Gray
- 7. Colors for Ungrounded Systems: Comply with applicable paragraphs of the current editions of NFPA 70 and NFPA 99.
  - a. Conductor 1: Orange with a distinctive colored stripe other than white, green, or gray
  - b. Conductor 2: Brown with a distinctive colored stripe other than white, green, or gray
  - c. Conductor 3 (for three phase systems): yellow with a distinctive colored stripe other
- I. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- J. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
  - 1. Outdoors: UV-stabilized nylon.
  - 2. In Spaces Handling Environmental Air: Plenum rated.
- K. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
- L. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

## 3.2 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Multi-Conductor Cables More Than 600 V: Self-adhesive vinyl labels. Install labels at 10-foot maximum intervals.
- B. Accessible Raceways and Multi-Conductor Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30A, and 120V to ground: Identify with self-adhesive vinyl label. Install labels at 10-foot (3-m) maximum intervals.
- C. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands every 10 lineal feet:
  - 1. Fire Alarm System: Red.
  - 2. Fire-Suppression Supervisory and Control System: Red and yellow.
  - 3. Combined Fire Alarm and Security System: Red and blue.

- 4. Security System: Blue and yellow.
- 5. Mechanical and Electrical Supervisory System: Green and blue.
- 6. Telecommunication System: Green and yellow.
- 7. Control Wiring: Green and red.
- D. Power-Circuit Conductor Identification, 600V or Less: Identify source and circuit number of each ungrounded conductor or set of conductors. For single conductor cables, identify phase in addition to the above.
  - 1. For conductors in pull and junction boxes, device boxes, and within 6-inches (153 mm) of termination use pre-printed marker tape.
  - 2. For conductors in vaults, manholes, hand holes and pull and junction boxes located in damp or wet locations use brass or stainless steel wraparound marker labels.
- E. Power-Circuit Conductor Identification, more than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation.
- F. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source and circuit number.
- G. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
  - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
  - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
  - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
- H. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply baked-enamel warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
  - 1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
    - a. Power transfer switches.

- b. Main-Tie-Main Switchboards
- c. Generator Paralleling Switchgear.
- d. Controls with external control power connections.
- 2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
- 3. Arc Flash Warning Labels: Apply label to door or cover at all access point of equipment including, but not limited to, the following:
  - a. Disconnect switches.
  - b. Electrical substations.
  - c. Electrical switchgear and switchboards.
  - d. Emergency system boxes and enclosures.
  - e. Enclosed circuit breakers.
  - f. Meter Sockets and assemblies.
  - g. Motor starters.
  - h. Motor-control centers.
  - i. Panelboards.
  - j. Power transfer equipment. (ATS)
  - k. Transformers.
  - 1. Uninterruptible power supply equipment.
- J. Available Fault Current Field Marking: Apply label to cover of existing and new service equipment enclosure with the date in which the fault current was calculated and the available fault current as determined by the OCPD coordination study. Table 1 below lists a typical example of label format, coordinate project specific requirements with Drawings.

Table 1 (Example Only)	
MAX. AVAILABLE FAULT: XX,XXXA	
DATE: X/X/XX	

K. Junction Boxes and Pull Boxes: Identify voltage, source, and circuit number(s) on cover of pull and junction boxes with hand-written legible block lettering using black permanent marking pen.

- L. Color Coding of Junction Boxes and Pull Boxes: Identify system on cover of pull and junction boxes using colored enamel spray paint. Where two colors are indicated identify each half of box with colors indicated.
  - 1. Power Circuits:
    - a. Normal: Match existing Verify with Owner
    - b. Emergency Legally Required Standby or Essential Electrical System prior to ATS: Match existing - Verify with Owner
    - c. Emergency Optional Standby: Match existing Verify with Owner
    - d. Life Safety Branch: Match existing Verify with Owner
    - e. Critical Branch: Match existing Verify with Owner
    - f. Equipment Emergency System: Match existing Verify with Owner
    - g. Non-Essential Emergency System: Match existing Verify with Owner
    - h. UPS: Match existing Verify with Owner
  - 2. Fire Alarm System: Match existing Verify with Owner
  - 3. Fire-Suppression Supervisory and Control System: Match existing Verify with Owner
  - 4. Combined Fire Alarm and Security System: Match existing Verify with Owner
  - 5. Security System: Match existing Verify with Owner
  - 6. Mechanical and Electrical Supervisory System: Match existing Verify with Owner
  - 7. Telecommunication System: Match existing Verify with Owner
  - 8. Control Wiring: Match existing Verify with Owner
  - 9. Nurse Call: Match existing Verify with Owner
  - 10. Public Address / Intercom: Match existing Verify with Owner
  - 11. CATV / MATV: Match existing Verify with Owner
  - 12. Clock: Match existing Verify with Owner
- M. Instruction Signs:
  - 1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

- 2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer, load shedding, Kirk Key Controlled Breakers
- N. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual.
  - 1. Labeling Instructions:
    - a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where 3 lines of text or more are required, use label height as required to accommodate 3/8-inch-high letters.
    - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label drilled and attached with corrosion-resistant screws.
    - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor per ANSI A13.1.
    - d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
  - 2. Distribution Equipment with Overcurrent Protective Devices to be labeled:
    - a. Provide for each of the following and any other similar equipment furnished under this Division identification as to its given name, voltage, origination of service, branch, and amps rated interrupting. Obtain final room number from Owner and Signage and Graphics Package. Table 2 below lists typical examples of label format, coordinate project specific requirements with Drawings:
      - 1) Electrical switchgear and switchboards.
      - 2) Panelboards.
      - 3) Electrical substations.
      - 4) Motor-control centers.
      - 5) Enclosed switches.
      - 6) Enclosed circuit breakers.

#### Table 2 (Examples Only)

EMERGENCY SYSTEM	NORMAL	LIFE SAFETY BRANCH
'EMSA'	<i>'1DPHA'</i>	ʻ1LSHA'
480Y/277V	480Y/277V	480Y/277V
FED FROM 'GEN-1'	FED FROM 'MSA'	FED FROM 'DPLSHA'
RM #XXXX	RM #XXXX	RM #XXXX
RATED INTERRUPTING: XX,XXXA	RATED INTERRUPTING: XX,XXXA	RATED INTERRUPTING: XX,XXXA

EQUIPMENT SYSTEM	CRITICAL BRANCH	NON-ESSENTIAL
'1EQLA'	'1CRHA'	'1DPCH-N'
208Y/120V	480Y/277V	480Y/277V
FED FROM 'T1EQLA'	FED FROM 'ATS-CR'	FED FROM 'ATS-N'
RM #XXXX	RM #XXXX	RM #XXXX
RATED INTERRUPTING: XX,XXXA	RATED INTERRUPTING: XX,XXXA	RATED INTERRUPTING: XX,XXXA
NORMAL	NORMAL	EQUIPMENT SYSTEM
<i>'CHP-1'</i>	<i>'AHU-1'</i>	<i>'HWP-1'</i>
480Y/277V	480Y/277V	480Y/277V
FED FROM 'MCC-1'	FED FROM '1DPHA'	FED FROM 'CPEQHA'
RM #XXXX	RM #XXXX	RM #XXXX
RATED INTERRUPTING: XX,XXXA	RATED INTERRUPTING: XX,XXXA	RATED INTERRUPTING: XX,XXXA

- 3. Distribution Equipment without Overcurrent Protective Devices to be labeled:
  - a. Provide for each of the following and any other similar equipment furnished under this Division identification as to its given name, voltage, origination of service, and branch. Table 3 below lists typical examples of label format, coordinate project specific requirements with Drawings:
    - 1) Electrical cabinets, and enclosures.
    - 2) Enclosed Bus Assemblies.
    - 3) Transformers: Label that includes tag designation for the transformer, feed, and panelboards or equipment supplied by the secondary.
    - 4) Disconnect switches.
    - 5) Emergency system boxes and enclosures.
    - 6) Enclosed controllers.
    - 7) Variable-speed controllers.
    - 8) Push-button stations.
    - 9) Power transfer equipment (ATS) Label both sources.
    - 10) Auxiliary Equipment (SPD, Capacitor Banks, etc.).
    - 11) Contactors.
    - 12) Fire-alarm control panel and annunciators.
    - 13) Uninterruptible power supply equipment.

#### Table 3 (Examples Only)

- ····································		
CRITICAL BRANCH	EQUIPMENT SYSTEM	OPTIONAL STANDBY SYSTEM
'T2CLA'	'ATS EQ'	'ATS SS'
75 KVA, 480V to 208Y/120V	480Y/277V	480Y/277V
FED FROM '2CHA'	FED FROM 'MSA' NORMAL	FED FROM 'MSA' NORMAL
FEEDS '2CRLA'	FED FROM 'EMSA' EMERGENCY	FED FROM 'EMSA' EMERGENCY

		FEEDS '	IEQHA'	FEEDS 'ISSHA'	
4.	Other Equip	oment to be labeled:			
	a. Provide for each of the following and any other similar equipment furnished und this Division identification as to its given name.				
	1)	Access doors and panels for concealed electrical items.			
	2)	Remote-controlled sw	vitches, dimmer 1	nodules, and control devices.	
	3)	Battery inverter units.			
	4)	Battery racks.			
	5)	Power-generating uni	ts, including rem	ote emergency stop switches.	
	6)	UPS equipment.			
	7)	Voice and data cable	terminal equipmo	ent.	
	8)	Master clock and prog	gram equipment.		
	9)	Intercommunication a	and call system m	naster and staff stations.	
	10)	Television/audio com	ponents, racks, a	nd controls.	
	11)	Security and intrusion cabinets, and racks.	n-detection con	trol stations, control panels, terminal	
	12)	Monitoring and control	ol equipment.		
	13)	Terminals, racks, and for signal and control	l patch panels for functions.	or voice and data communication and	
5.	Provide for each feeder overcurrent protective device in each switchgear, switchboard, distribution panelboard, motor control center, and any other similar equipment furnished under this Division, identification as to the specific load that it serves.				
6.	Provide for equipment.	each 3 phase motor:	brass phase r	otation tags securely attached to the	
		END OI	<b>SECTION</b>		

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Devenney Group Ltd., Project No. 6406.24.0003 HCA - Lee's Summit Medical Center ED Expansion

IDENTIFICATION FOR ELECTRICAL SYSTEMS 260553 - 16

## **SECTION 265619**

## LED EXTERIOR LIGHTING

## PART 1 - GENERAL

### 1.1 SUMMARY

- A. This Section includes the following:
  - 1. Exterior luminaires.
  - 2. Solid State luminaire, and drivers.
  - 3. Luminaire-mounted photoelectric relays.
  - 4. Poles and accessories.
  - 5. Materials.
  - 6. Finishes.
  - 7. Luminaire support components.
- B. Related Sections include the following:
  - 1. Division 26 Section "Interior Lighting" for exterior luminaires normally mounted on interior surfaces of buildings.
  - 2. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

## 1.2 DEFINITIONS

- A. CCT: Correlated Color Temperature.
- B. CRI: Color-rendering index.
- C. CU: Coefficient of utilization.
- D. EPA: Equivalent projected area.
- E. FMG: FM Global (formally Factory Mutual).
- F. Fixture: See "Luminaire."
- G. IP: International Protection or Ingress Protection Rating.
- H. LED: Light emitting diode.

- I. LER: Luminaire efficacy rating.
- J. Lumen: Measured output of lamp and luminaire, or both.
- K. Luminaire: Complete Lighting unit including, lamps, reflector, and housing.
- L. Pole: Luminaire support structure, including tower used for large area illumination.
- M. Standard: Same definition as "Pole" above.
- N. Solid State: Lighting products that use semiconductor light-emitting diodes (LEDs), organic light-emitting diodes (OLED), or polymer light-emitting diodes (PLED) as sources of illumination rather than electrical filaments, plasma, or gas.
- O. TM-21-19 L70: The time it takes a Luminaire to reach 70% Lumen maintenance based on extrapolations from LM-80-15 date using the approved methods required in IESNA Technical Memorandum 21 (TM-21-19).

#### 1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design support bases and select poles and other support components for the standard mounted luminaires proposed for inclusion in the Work. Include comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

#### 1.4 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

- A. Dead Load: Weight of luminaire and its horizontal and vertical supports and supporting structure, applied as stated in AASHTO LTS-4.
- B. Ice Load: Load of 3 lbf/sq. ft., applied as stated in AASHTO LTS-4.
- C. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.

#### 1.5 ACTION SUBMITTALS

- A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section "Common Work Results for Electrical" for products specified under PART 2 - PRODUCTS.
- B. Product Data: For each type of luminaire, arranged in order of fixture unit designation. Include data on features, accessories, finishes and the following:
  - 1. Physical description of luminaire including materials, dimensions, and verification of indicated parameters.
  - 2. Emergency lighting units including battery and charger.
  - 3. Performance data for drivers.
  - 4. LED: include life, output (lumens, CCT, and CRI), and energy-efficiency data.

- 5. Photometric data, in IESNA LM-63-19 format, based on laboratory tests of each luminaire type, complete with indicated LEDs, drivers, and accessories identical to those indicated for the luminaire as applied in this Project.
  - a. Provide optical performance, polar diagrams, and relevant luminance and illuminance photometric data.
  - b. Photometric data shall be certified by a qualified independent testing agency or by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
- 6. Photometric data and adjustment factors based on laboratory tests, complying with IES "Lighting Measurements Testing and Calculation Guides" for each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project, IES LM-79, or IES LM-80.
  - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
  - b. LM-79 luminaire photometric reports for Solid State luminaires. The test laboratory must hold National Voluntary Laboratory Accreditation Program (NVLAP) accreditation for the IES LM-79 test procedure or must be qualified, verified, and recognized through the U.S. Department of Energy's CALiPER program.
- 7. Solid State Luminaire reliability reports indicating that the manufacturer of the LED (chip, diode, or package) has performed JEDEC (Joint Electron Devices Engineering Council) reliability tests on the LEDs as follows:
  - a. High Temperature Operating Life (HTOL)
  - b. Room Temperature Operating Life (RTOL)
  - c. Low Temperature Operating Life (LTOL)
  - d. Powered Temperature Cycle (PTMCL)
  - e. Non-Operating Thermal Shock (TMSK)
  - f. Mechanical shock
  - g. Variable vibration frequency
  - h. Solder Heat Resistance (SHR)
- 8. Photoelectric relays.
- 9. Performance data for drivers, including energy-efficiency data.

- 10. LEDs, including life, output, and energy-efficiency data.
- 11. Include data on construction pole details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components
- 12. Materials, dimensions, and finishes of poles.
- 13. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
- 14. Anchor bolts for poles.
- C. Shop Drawings:
  - 1. Include plans, elevations, sections, and mounting and attachment details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Detail fabrication and assembly of poles and pole accessories.
  - 4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
  - 5. Method and procedure of pole installation. Include manufacturer's written installations
  - 6. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
  - 7. Support base design, certified by a qualified professional engineer, indicating installation details of pole foundations and soil conditions on which they are based.
  - 8. Wiring Diagrams: Power and control wiring.
  - 9. Photometric Calculation Drawings: overall site plan prepared using computerized pointby-point analysis software based on luminaires proposed for inclusion in the Work. Plans shall indicate the following:
    - a. Illuminance levels at grade on a maximum of a 24-inch by 24-inch grid.
    - b. Schedule of Luminaires, include the following:
      - 1) Make and Model number of Luminaires.
      - 2) Description of Luminaire; including mounting and accessories.
      - 3) Lamps, including initial and maintained lumen output.
      - 4) Assumed light loss factors used in calculations.

- c. Calculation Summery showing the following:
  - 1) Average Illuminance.
  - 2) Minimum to Maximum Ratio.
  - 3) Average to Minimum Ratio.
  - 4) Maximum illuminance at Property Line
- 10. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
- D. Finish Samples for Verification: Nominal 3-inch by 3-inch metal squares, factory finished for all standard finishes available; indicate specified finish with unique tag or marker.
- A. Delegated-Design Submittal: For luminaire supports.
  - 1. Include design calculations for luminaire supports.

#### 1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Submit Reflected Ceiling Coordination Drawings in accordance with Division 26 Section "Common Work Results for Electrical."
- B. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4 and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations signed and sealed by a professional engineer.
- C. Product Test Reports: For each type of luminaire, for tests performed by a qualified testing agency.
- D. Qualification Data: For agencies providing photometric data for Luminaires.
- E. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- F. Material Test Reports:
  - 1. For each foundation component, by a qualified testing agency.
  - 2. For each pole, by a qualified testing agency.
- G. Field quality-control test reports.
- 1.7 CLOSEOUT SUBMITTALS
  - A. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation And Maintenance Data," include the following:

- 1. Manufacturer's routine maintenance requirements for lighting and all installed components.
- 2. Special LED and driver disposal requirements; including manufacturer's safety data sheet with EPA requirements.
- 3. Pole repair materials.
- B. Warranty: Special warranty specified in this Section.

# 1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
  - 2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
  - 3. Drivers: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
  - 4. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

## 1.9 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7.
- C. Source Limitations: All luminaries and poles with the same type designation shall be obtained from a single manufacturer. Obtain similar luminarie types through one source from a single manufacturer, unless otherwise indicated.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
- F. Comply with IEEE C2, "National Electrical Safety Code."

- G. Comply with NFPA 70.
- H. Testing Agency Qualifications: Qualified according to ASTM C1093 for foundation testing.

# 1.10 DELIVERY, STORAGE, AND HANDLING

- A. Prepare products for shipment.
  - 1. Provide suitable packaging materials, crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.
  - 2. Weatherproof packaging for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.
- B. Store luminaires in clean dry area in accordance with manufacturer's requirements. Protect products from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- C. Handle product components according to manufacturer's written instructions.
- D. Package aluminum poles for shipping according to ASTM B 660.
- E. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- F. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

#### 1.11 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

#### 1.12 WARRANTY

- A. Special Warranty for Luminaire and Luminaire Accessories: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, or unauthorized repairs or alterations from special warranty coverage. Manufacturer may exclude vandalism or abuse for luminaires that are not designated as high-abuse products where vandal resistance is a product requirement.
  - 1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
  - 2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
  - 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.

- 4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.
- B. Special Warranty for Solid State Power Supplies and Drivers: Manufacturer's standard form, made out to Owner and signed by manufacturer agreeing to replace power supplies or drivers that fail in materials or workmanship, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.
  - 1. Warranty Period: 60 months from date of Substantial Completion.
- C. Special Warranty for LED: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Five years from date of Substantial Completion.

# PART 2 - PRODUCTS

# 2.1 MANUFACTURERS

- A. Provide luminaires in accordance with the designations and descriptions in the "Luminaire Schedule" located on the Drawings. In Luminaire Schedule, products are listed below column or row headings that introduce lists, the following requirements apply to product selection:
  - 1. Specific Product: Where the Luminaire Schedule indicates only one product by manufacturer and associated catalog number and does not list other manufacturers by name and includes the phrase "NO SUBSTITUTIONS ALLOWED"; the design for each luminaire is based on the product named by manufacturer and associated catalog number scheduled. Subject to compliance with requirements, provide the product named by the manufacturers specified. Provide a list of Unit Prices for these items in accordance with requirements of Division 01 Section "Unit Prices".

## 2.2 LUMINAIRES, GENERAL REQUIREMENTS

- A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
- B. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- C. Metal Parts: Free of burrs and sharp corners and edges.
- D. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.
- E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- F. Metal Finishes:

- 1. Steel:
  - a. ASTM A36/A36M for carbon structural steel.
  - b. ASTM A568/A568M for sheet steel.
- 2. Stainless Steel:
  - a. Manufacturer's standard grade.
  - b. Manufacturer's standard type, ASTM A240/240M.
- 3. Galvanized Steel: ASTM A653/A653M.
- 4. Aluminum: ASTM B209.
- 5. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.
- G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect driver when door opens.
- H. Exposed Hardware Material: Stainless steel.
- I. Diffusers and Globes:
- J. Plastic Diffusers, Covers, and Globes:
  - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
    - a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless different thickness is indicated.
    - b. UV stabilized.
  - 2. Glass: Annealed crystal glass, unless otherwise indicated.
- K. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field, where indicated in Luminaire Schedule.
- L. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
  - 1. White Surfaces: 85 percent.
  - 2. Specular Surfaces: 83 percent.

- 3. Diffusing Specular Surfaces: 75 percent.
- M. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- N. Luminaire Finish: Finish as indicated in Luminaire Schedule. Manufacturer's standard paint or clear coat finish and custom Colors where indicated; applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- O. Structural Characteristics: Comply with AASHTO LTS-6-M.
- P. Dead Load: Weight of luminaire and its horizontal and vertical supports, and supporting structure, applied according to AASHTO LTS-6-M.
- Q. Live Load: Single load of 500 lbf (2200 N) distributed according to AASHTO LTS-6-M.
- R. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied according to AASHTO LTS-6-M for applicable areas on the Ice Load Map.
- S. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.
  - 1. Basic wind speed for calculating wind load for poles exceeding 50 feet (15 m) in height is 100 mph (45 m/s).
    - a. Wind Importance Factor: 1.0.
    - b. Minimum Design Life: 50 years.
    - c. Velocity Conversion Factor: 1.0.
  - 2. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is 100 mph (45 m/s).
    - a. Wind Importance Factor: 1.0 from AASHTO LTS-6-M.
    - b. Minimum Design Life: 25 years from AASHTO LTS-6-M.
    - c. Velocity Conversion Factor: 1.0 from AASHTO LTS-6-M.
- T. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.
- U. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

#### 2.3 EMERGENCY POWER UNIT

A. Manufacturers: Listed and labeled with the luminaire.
- B. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with driver. Comply with UL 924.
  - 1. Emergency Connection: Operate one driver(s) continuously at 30% full lumen output, each, for a minimum of 90 minutes, unless otherwise indicated. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture driver.
  - 2. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
    - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    - b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
  - 3. Battery: UL924, UL1310 compliant.
  - 4. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.

### 2.4 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

- A. Comply with UL 773 or UL 773A.
- B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
  - 1. Relay with locking-type receptacle shall comply with NEMA C136.10.
  - 2. Adjustable window slide for adjusting on-off set points.
    - a. Relay with locking-type receptacle shall comply with ANSI C136.10.
    - b. Adjustable window slide for adjusting on-off set points.

# 2.5 SOLID STATE LIGHTING SYSTEMS

- A. Solid State luminaires will comply with the requirements of the following standards:
  - 1. ANSI/NEMA/ANSLG C78.377-2008 American National Standard for the Chromaticity of Solid State Lighting Products.
  - 2. LM-79, IESNA Approved Method for the Electrical and Photometric Measurements of Solid-Sate Lighting Products.
  - 3. LM-80, IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources.

- B. LED Chip Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Osram.
  - 2. Philips LumiLEDs.
  - 3. Nichia.
  - 4. Cree.
  - 5. Seoul Semi-Conductor.
  - 6. Xicato.
  - 7. Bridgelux.
- C. General: Provide Solid State systems and LED components meeting the following requirements:
  - 1. Provide Solid State systems from same binning process to maintain color consistency.
  - 2. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
  - 3. Deliver all Solid State products at the same time and store on site to ensure that products have been produced from the same bin. Tolerances exceeding 200K will not be acceptable.
  - 4. The Solid State Luminaires shall be operated at constant and carefully regulated current levels. LEDs shall not be overdriven beyond their specified nominal voltage and current.
  - 5. Provide Electrical connections protected from reverse polarity. Provide high voltage protection in the event connections are reversed or shorted during the installation process.
  - 6. Provide Solid State Luminaires and power/data supplies from a single manufacturer to ensure compatibility.
  - 7. Provide all Solid State controls, peripheral devices, and software from a single manufacturer to ensure compatibility.
  - 8. Conduct minimum eight-hour burn-in test during manufacturing on Solid State Luminaires (100% of each lot).
- D. White & Static Color Solid State Systems: White LED sources must meet the following requirements:
  - 1. Luminaires must be rated for  $-40^{\circ}$ C to  $+50^{\circ}$ C operation.
  - 2. Duv tolerance of  $0.001 \pm 0.006$ .

- 3. Color Rendering Index (CRI): greater than or equal to 80.
- 4. Correlated Color Temperature (CCT) as Specified in Luminaire Schedule. Meet the following tolerance requirements for CCT specified:
  - a. Nominal 2700K CCT: 2725 ± 50.
  - b. Nominal 3000K CCT: 3045 ± 50.
  - c. Nominal 3500K CCT:  $3465 \pm 50$ .
  - d. Nominal 4000K CCT: 3985 ± 50.
  - e. Nominal 4500K CCT:  $4503 \pm 50$ .
  - f. Nominal 5000K CCT: 5028 ± 50.
  - g. Nominal 5700K CCT: 5665 ± 50.
  - h. Nominal 6500K CCT:  $6530 \pm 50$ .
- E. Dynamic Color Changing Solid State Systems: RGB LED sources must meet the following requirements:
  - 1. Luminaires must be rated for  $-40^{\circ}$ C to  $+50^{\circ}$ C operation.
  - 2. Duv tolerance of  $0.001 \pm 0.006$ .
  - 3. Color Rendering Index (CRI): greater than or equal to 80 for RGB mixed white.
  - 4. Controllability:
    - a. 8-bit control of red, green and blue LEDs to produce 16.7 million colors or more.
    - b. Digital driver using high-speed pulse width modulation (PWM).
    - c. Integral and differential nonlinear control.
    - d. 14-bit or greater nonlinear scaling techniques for high-resolution output.
    - e. Selectable means of external control via a data network.
    - f. Support frame rates greater than 30 frames per second.
    - g. Constant data transmission rates shall be employed, resulting in the output being independent of distance of cable between power supply and light source within the specified length.

### 2.6 DRIVERS FOR SOLID STATE LIGHTING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Lutron Electronics Co., Inc.
  - 2. OSRAM Sylvania.
- B. Description: Electronic programmed rapid-start type, complying with FCC Part 15 Class A or Class B, designed for type and quantity of LEDs indicated. Driver shall be designed for full light output and include dimming capability.
  - 1. Compatibility: Certified by manufacturer for use with LED type provided.
  - 2. Comply with UL 8750 Class 2.
  - 3. Thermal Protection: Comply with UL Class P, Type 1 Outdoor.
  - 4. Sound Rating: Class A.
  - 5. Total Harmonic Distortion Rating: Less than 10 percent.
  - 6. Transient Voltage Protection: ANSI/IEEE C62.41, Category A or better.
  - 7. Input Voltage Range: 108-305 Volts.
  - 8. Output Voltage: not exceeding 60V (Complies with Class 2 for US).
  - 9. Maximum inrush current: 2 amperes for 120V and 277V drivers.
  - 10. Minimum Efficiency at Full Load: 85%.
  - 11. Power Factor: 0.9 or higher.
  - 12. Starting Temperature: Minus 5 Deg F (Minus 20 Deg C) minimum to 104 Deg F (40 Deg C), unless otherwise indicated.
  - 13. Case Temperature: 75 Deg C maximum, unless otherwise indicated or used in LM70 reporting.
  - 14. Housing: minimum IP20 rating for dry location installation, higher rating as required for exterior use.
  - 15. Remote Mounting Distance: Up to 18-feet, where indicated.
  - 16. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
  - 17. Rated Life: minimum of 50,000 hours of rated lifetime at maximum operating conditions.

18. Dimmable with standard dimmers down to 1%. 0-10V, 3-wire, or 3. Forward Phase Control (neutral wire required) (Line Voltage Controlled) Dimming as required to be compatible with lighting control system specified.

### 2.7 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

- A. Structural Characteristics: Comply with AASHTO LTS-4.
  - 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.
  - 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.
- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
  - 1. Materials: Shall not cause galvanic action at contact points.
  - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.
  - 3. Anchor-Bolt Template: Plywood or steel.
- D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

### 2.8 STEEL POLES

- A. Poles: Comply with ASTM A 500/A500M, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
  - 1. Shape: As indicated in Luminaire Schedule on Drawing.
- B. Brackets for Luminaires: Detachable, cantilever, without underbrace.
  - 1. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
  - 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
  - 3. Match pole material and finish.

- C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- D. Fasteners: Stainless steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
  - 1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
  - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
- E. Grounding and Bonding Lugs: Welded 1/2-inch (13 mm) threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- F. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- G. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
  - 2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
  - 3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
    - a. Color: As indicated in Luminaire Schedule

# 2.9 ALUMINUM POLES

- A. Poles: Seamless, extruded structural tube complying with ASTM B 221, Alloy 6063-T6 with access handhole in pole wall.
- B. Poles: ASTM B 209, 5052-H34 marine sheet alloy with access handhole in pole wall.
  - 1. Shape: As indicated in Luminaire Schedule on Drawings.
  - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

- A. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
  - 1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
  - 2. Finish: Same as luminaire, unless otherwise indicated.
- B. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- C. Grounding and Bonding Lugs: Welded 1/2-inch (13 mm) threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- A. Fasteners: Stainless steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
  - 1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
  - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
- B. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.
- C. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- D. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
    - a. Color: As indicated in Luminaire Schedule.

# 2.10 POLE ACCESSORIES

- A. Duplex Receptacle, as indicated: Ground-fault circuit interrupter type 120 V, 20 A in a weatherproof assembly complying with Division 26 Section "Wiring Devices" for ground-fault circuit-interrupter type.
  - 1. Recessed, 36 inches (900 mm) above finished grade.
  - 2. Nonmetallic polycarbonate plastic or reinforced fiberglass cover, that when mounted results in NEMA 250, Type 3R enclosure.
  - 3. With cord opening.

- 4. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.
- B. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.
- C. Decorative accessories, supplied by decorative pole manufacturer, include the following as indicated:
  - 1. Banner Arms
  - 2. Flag Holders
  - 3. Ladder Rests

# PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine poles, luminaire-mounting devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.
- C. Examine roughing-in for luminaire and foundation electrical conduit to verify actual locations of conduit connections before luminaire installation.
- D. Examine walls, roofs, and canopy ceilings for suitable conditions where luminaires will be installed.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

# 3.2 LUMINAIRE INSTALLATION

- A. Comply with NECA IESNA 501 "Standard for Installing Exterior Lighting Systems" as published by the National Electrical Contractors Association.
- B. Fasten luminaire to indicated structural supports.
  - 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources.
- D. Supports:
  - 1. Sized and rated for luminaire weight.
  - 2. Able to maintain luminaire position after cleaning and relamping.

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- 3. Support luminaires without causing deflection of finished surface.
- 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- E. Wall-Mounted Luminaire Support:
  - 1. Attached to structural members in walls.
- F. Wiring Method: Install cables in raceways. Conceal raceways and cables.
- G. Install luminaires level, plumb, and square with finished grade unless otherwise indicated.
- H. Coordinate layout and installation of luminaires with other construction.
- I. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.
- J. Drivers: Provide multiple drivers as required to accommodate multilevel switching indicated on Drawings.

# 3.3 POLE INSTALLATION

- A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- B. Harmonic Dampener: Provide harmonic dampeners on conductors within pole.
- C. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:
  - 1. Fire Hydrants and Water Piping: 60 inches (1520 mm)
  - 2. Water, Gas, Electric, Communications, and Sewer Lines: 10 feet (3 m)
  - 3. Trees: 15 feet (5 m) from tree trunk.
- D. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- E. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
  - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
  - 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
  - 3. Install base covers, unless otherwise indicated.

- 4. Use a short piece of 1/2-inch (13 mm)-diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- F. Poles and Pole Foundations Set in Concrete Paved Areas: Install saw-cut or formed control joint in concrete slab within 12-inches of pole or pole foundation. Coordinate with Division 32 Section "Concrete Paving."
- G. Raise and set poles using web fabric slings (not chain or cable).

# 3.4 BOLLARD LUMINAIRE INSTALLATION

- A. Align units for optimum directional alignment of light distribution.
- B. Install on concrete base with top 4 inches above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

# 3.5 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

A. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

# 3.6 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Division 26 Section "Underground Ducts and Raceways for Electrical Systems." In concrete foundations, wrap conduit with 20 mil polyvinyl chloride (PVC) tape with a high-tack adhesive and pipe primer to provide a corrosion- and impactresistant seal. Apply with a 50 percent overlap.

# 3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

# 3.8 CONNECTIONS

- A. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Secure all wiring routed inside poles using cable support grips. Remove slack in conductors to prevent lateral movement.

### 3.9 GROUNDING

- A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
  - 1. Install grounding electrode for each pole.
  - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
  - 1. Install grounding electrode for each pole.
  - 2. Install grounding conductor and conductor protector.
  - 3. Ground metallic components of pole accessories and foundations.

# 3.10 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Test for Emergency Lighting: Verify transfer from normal power to battery and retransfer to normal by both of the following methods.
  - 1. Interrupt power supply to demonstrate proper operation.
  - 2. Depress Push-To-Test button to demonstrate proper operation.
- C. Perform the following tests and inspections:
  - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
  - 2. Verify operation of photoelectric controls.
  - 3. Illumination Tests: Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with requirements of authorities having jurisdiction and the following IESNA testing guide(s):
    - a. IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
    - b. IESNA LM-64, "Photometric Measurements of Parking Areas."
- D. Luminaire will be considered defective if it does not pass tests and inspections.
- E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards and design requirements.

# 3.11 CLEANING AND RELAMPING

- A. Clean components according to manufacturer's written instructions.
- B. After completing equipment installation and before substantial completion, inspect all luminaires and components.
  - 1. Remove paint splatters and other spots, dirt, fingerprints and debris.
  - 2. Repair damaged finish to match original finish.
  - 3. Dust or Vacuum interiors of luminaires to remove all dust, dirt, and debris.
  - 4. Clean all lenses with cleaning agent approved by Luminaire Manufacturer.
  - 5. Verify all warning labels in fixtures do not obstruct any reflective surface. Relocate warning labels as necessary so that they are not in plain view, yet they are still accessible to qualified personnel during driver replacement.

# 3.12 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
  - 1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
  - 2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
  - 3. Adjust the aim of luminaires in the presence of the Architect.

# **END OF SECTION**