

PIKES PEAK PARKING RESTORATION

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SECTION 260400 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Certain labor, materials, and equipment may be furnished under other Sections of these specifications, by utility Companies or by the Owner. When this is the case, the extent, source and description of these items will be as indicated on the drawings or as described in the specifications.
- B. Where a panel is installed, at least 25% of panel capacity, accounting for serving panel capacity, shall remain as spare capacity after project completion.
- C. Where existing panels are used for additional work, when six (6) or less spaces remain a new panel shall be installed.
- D. All electrical/electronic circuits, including audio, video and fire alarm systems, shall be in an approved raceway system. No "wild circuits" will be accepted.
- E. The Designer of Record shall not design or specify and the Contractor shall not install rigid metal conduit, electrical metallic tubing, flexible steel conduit, liquid-tight flexible steel conduit, non-metallic rigid conduit or innerduct in any horizontal or vertical concrete wall or slab structures or portions thereof, e.g., cast-in-place concrete floor slab on steel decking; cast-in-place concrete slabs integral with concrete structural support systems; prestressed concrete slabs; post-tensioned concrete slabs; precast concrete construction with or without field applied or plant fabricated concrete topping slabs, slabs on grade, foundation walls or in concrete cast-in-place walls, etc.
- F. Related Sections:
 - 1. Basic Electrical Requirements specifically applicable to all Division 26 Sections, in addition to Division 1 General Requirements, and Divisions 11, 14, 21, 22, 23, 27 and 28.
 - 2. All electrical/electronic circuits and equipment from any other Division shall meet the requirements of Division 26.
 - 3. Description: Work shall consist of furnishing all labor, equipment, supplies, and materials, unless otherwise specified, necessary for the installation of complete electrical systems as required by the specifications and as shown on the drawings, subject to the terms and conditions of the Contract. The Work shall

also include the completion of those details of electrical work not mentioned or shown which are necessary for the successful operation of all electrical systems.

4. Temporary Power: See Division 1 for construction power constraints.

G. REFERENCE STANDARDS

H. Comply with the requirements of the reference standards noted herein, except where more stringent requirements are listed herein or otherwise required by the Contract Documents.

I. Latest editions of the following:

1. ANSI/NFPA 70 - National Electrical Code (as adopted and amended by the Denver Building Department).
2. International Fire Code (as amended by the Denver Fire Department).
3. International Building Code (as adopted and amended by the Denver Building Department).
4. International Energy Conservation Code (as adopted and amended by the Denver Building Department).
5. ANSI/IEEE C2 - National Electrical Safety Code.
6. OSHA - Occupational Safety and Health Administration, as Amended
7. Underwriter's Laboratory (UL).
8. National Fire Protection Association (NFPA).
9. Other references as listed elsewhere in these specifications.
10. IEEE Standard 519- Recommended Practices and Requirement for Harmonic Control in Electrical Power Systems.

1.3 DEFINITIONS

- A. "Furnish" or "Provide": To supply, install and connect complete and ready for safe and regular operation of particular work unless specifically otherwise noted.
- B. "Install": To erect, mount and connect complete with related accessories.
- C. "Supply": To purchase, procure, acquire and deliver complete with related accessories.
- D. "Work": Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.
- E. "Wiring": Raceway, fittings, wire, boxes and related items.
- F. "Concealed": Embedded in masonry, concrete or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures.
- G. "Or Equal. Or Approved Equal": Refers to products that, in the opinion of the DEN Project Manager, are similar in all respect to products specified by proprietary brand

name. (Refer to Section 01630 for procedures for submittal of proposed substitutions.)

- H. "Exposed": Not installed underground or "concealed" as defined above.
- I. "Indicated," "Shown" or "Noted": As indicated, shown or noted on drawings or specifications.
- J. "Similar" or "Equal": Same in materials, weight, size, design, construction, capacity, performance, and efficiency of specified product.
- K. "Reviewed," "Satisfactory," "Accepted," or "Directed": As reviewed, satisfactory, accepted, or directed by or to DEN Project Manager.
- L. "Related Work" includes all "Work" required for a complete working system.
- M. "Equipment": A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as a part of, or in connection with, an electrical installation.
- N. "Busbar": A rigid metallic conductor, lug or bar used to make a common connection between more than one circuit. (Includes all termination assemblies.)
- O. "Shall": Mandatory requirements of this specification are characterized by the use of the word "shall".
- P. Refer to Article 100 of the currently adopted National Electrical Code for other definitions as applicable to this Project.

1.4 WORK SEQUENCE

- A. Construct Work in sequence under provisions of Division 1 where applicable.

1.5 DRAWINGS AND SPECIFICATIONS

- A. The Drawings indicate the general arrangement of circuits, outlets, panelboards and other work. Information shown on the Drawings is schematic; however, re-circuiting will not be permitted without specific acceptance. In cases of conflict between specifications and drawings, the specification shall have precedence. Data presented on the drawings is as accurate as planning can determine, but accuracy is not guaranteed and field verification of all dimensions, locations, levels, etc., to suit field conditions is required. Review all of the Contract Documents and adjust all work to conform to all conditions shown therein.
- B. Prior to submitting a bid, a site visit is required to ascertain all conditions affecting the proposed installation and to adjust all work accordingly. Costs for providing for these adjustments, including response to site constraints, shall be itemized and listed in the bid proposal.

- C. Discrepancies between different plans, between plans and specifications, between specifications, or regulations and codes governing this installation shall be brought to the attention of the DEN Project Manager in writing 72 hours before the date of bid opening. In the event such discrepancies exist, and the DEN Project Manager is not so notified, the adjudication of responsibility shall be solely at the discretion of the DEN Project Manager.

1.6 COORDINATION

- A. Prior to fabrication or installation of any electrical work, participate in detailed coordination planning meetings with all other building utilities system trades, under the direction of the General Contractor, so as to completely establish routings, elevations, space requirements, and coordination of access, layout, and suspension requirements in relationship to the building structure and the work of all other trades.
- B. Any electrical work penetrating concrete walls or floors shall require saw cutting and/or core drilling and shall require approval by the DEN Project Manager. The Contractor shall perform all necessary imaging (x-rays, etc.) as specified, and submit shop drawings of any saw cutting or core drilling to the DEN Project Manager prior to performing the Work. Refer to Section 017330 "Cutting and Patching" for additional requirements.
- C. Any power outages necessary to install or test electrical systems and/or equipment shall be coordinated with Denver International Airport Maintenance/Engineering. A written shutdown request form shall be submitted to and approved by the DEN Project Manager two (2) weeks prior to the shutdown.

1.7 COORDINATION DRAWINGS

- A. Where the Contractor modifies the design, through selection of equipment differing from that shown, coordination drawings shall be provided by the Contractor in accordance with Division 1 to a scale of 1/4"=1'0" or larger for equipment rooms, details, congested areas and sections; other plans at a scale of 1/8"=1'0". These drawings are to detail major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components.
- B. Coordination drawings shall be in accordance with current DEN standards for format, and as outlined in Division 1.
- C. The Contractor shall indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
 - 1. Indicate the proposed locations of raceway systems, equipment, and materials. Include the following:

- a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
 - b. Exterior wall and foundation penetrations.
 - c. Fire-rated wall and floor penetrations.
 - d. Equipment connections and support details.
 - e. Sizes and location of required concrete pads and bases.
 - f. Support details.
2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
 3. Floor plans, elevations, and appropriate details are required to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

1.8 SUBMITTALS

- A. Refer to Section 013300 "Submittal Procedures".
- B. Submit shop drawings, coordination drawings and product data in accordance with provisions of Division 1. Submit all required information under a given specification section together. Do not split out submittals under the same specification section.
- C. Prior to submission, shop drawings, material lists and catalog cut sheets or manufacturer's printed data shall be thoroughly checked for compliance with Contract requirements, compatibility with equipment being furnished by the Contractor or Owner, accuracy of dimensions, coordination with work of other trades, and conformance with sound and safe practice as to erection of installation. Each submittal shall bear Contractor's signed statement evidencing such checking.
- D. Clearly mark each shop drawing as follows for purposes of identification:
 1. Shop Drawing.
 2. Equipment Identification Used on Contract Drawings.
 3. Date.
 4. Name of Project.
 5. Branch of Work.
 6. Project Manager's Name.
 7. Contractor's Name.
- E. Clearly mark printed material, catalog cut sheets, pamphlets or specification sheets, and shop drawings with the same designation shown on the Contract document schedules. Contractor agrees that submittals processed by the DEN Project Manager are not change orders; that the purpose of submittals is to demonstrate to the DEN Project Manager that the Contractor understands the design concept; and that the Contractor demonstrates this understanding by indicating which equipment and material the Contractor intends to furnish and install and by detailing the installation methods the Contractor intends to use.

- F. Contractor shall be responsible for dimensions (which the Contractor shall confirm and correlate at the job site), fabrication processes and techniques of construction, and coordination of the Contractor's Work with that of other trades. The Contractor shall check and verify all measurements and review shop drawings before submitting them. If any deviations from the specified requirements for any item of material or equipment exist, such deviation shall be expressly stated in writing and incorporated with the submittal.
- G. Maintain one copy of accepted shop drawings at the Project field office until completion of the Project, and make this copy available, upon request, to representatives of the DEN Project Manager and Owner.
- H. No equipment or materials shall be installed or stored at the jobsite until submittals for such equipment or materials have been given review action by the DEN Project Manager accepting their use.
- I. Shop drawings and manufacturer's published data shall be submitted for all equipment required for this Project.

1.9 RECORD DOCUMENTS

- A. Maintain a Contract set of electrical drawings and specifications at the site. Neatly mark all changes, discoveries and deviations from the original drawings. Use a reproducible color that contrasts with the prints. This shall be a separate set of drawings, not used for construction purposes, and shall be updated daily as the job progresses and shall be made available for inspection by the DEN Project Manager at all times. Upon completion of the Contract, this set of record drawings shall be delivered to the DEN Project Manager. Follow current DEN BIM standards, to be furnished to the successful bidder as well as the project-specific BIM execution plan. Record documents to be provided by the Contractor shall clearly and accurately show the following:
 - 1. Provide horizontal and vertical dimensions for all raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
 - 2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 - 3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.10 REGULATORY REQUIREMENTS

- A. Obtain all permits, plan review, and inspections from authority having jurisdiction.
- B. The drawings and specifications take precedence when they are more stringent than codes, statutes, or ordinances in effect. Applicable codes, ordinances, standards and

statutes take precedence when they are more stringent than the drawings and specifications.

1.11 ENVIRONMENTAL CONDITIONS

- A. The equipment shall be designed and constructed to operate successfully at the rated values under the following environmental conditions:
1. Location: Indoors/Outdoors.
 2. Altitude: 5,500 feet above sea level.
 3. Temperature range: -30°F to 120°F.

1.12 WARRANTY

- A. The entire electrical system installed under this Contract shall be left in proper working order. Replace, at no additional cost to the Owner, any work, materials, or equipment which evidences defects in design, construction, or workmanship within two (2) years, or any longer period specifically noted elsewhere in these specifications, from date of substantial completion.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and Equipment: Acceptable to the authority having jurisdiction as suitable for the use intended, except where more stringent requirements are indicated by the Contract Documents.
- B. All equipment and materials installed shall be new, unless otherwise specified.
- C. Defective or damaged materials shall be replaced or repaired, prior to final acceptance, in a manner acceptable to the DEN Project Manager or Owner and at no additional cost to the Owner.
- D. All electrical "equipment" and assemblies shall be acceptable for installation only if labeled and listed by a nationally recognized testing laboratory, such as UL or an equivalent.
- E. All major equipment components shall have the manufacturer's name, address, model number, and serial number permanently attached in a conspicuous location.

2.2 STORAGE AND PROTECTION

- A. Store products in accordance with manufacturer's instructions, with seals and labels

intact and legible. Store sensitive products in weather-tight enclosures; maintain within temperature and humidity ranges required by manufacturer's instructions.

- B. For exterior storage of fabricated products, place on sloped supports above ground. Cover products subject to deterioration with impervious sheet covering and provide ventilation to avoid condensation.
- C. Arrange storage to provide access for inspection. Periodically inspect to assure products are undamaged and are maintained under required conditions.

2.3 PRODUCT OPTIONS

- A. Products Specified by Reference Standards or by Description Only:
 - 1. Any product meeting those standards.
- B. Products Specified by Naming One or More Manufacturers with a Provision for Substitutions:
 - 1. Submit a request for substitution for any manufacturer not specifically named with supporting documentation for approval by DEN Project Manager.

2.4 PRODUCTS LIST

- A. Within fifteen (15) days after date of Notice to Proceed, submit complete list of major products required for submittal under these specifications, with name of manufacturer, trade name, and model number of each product.

2.5 SUBSTITUTIONS

- A. Refer to Division 1 General Requirements, Section 012510 "Substitutions".

PART 3 - EXECUTION

3.1 WORKMANSHIP

- A. Only quality workmanship will be accepted. Poor workmanship, improper layout of work and lack of coordination of Work, as determined by the DEN Project Manager, are not acceptable and shall be corrected at the contractors cost.
- B. Contractor shall include no more than one apprentice per Journeyman Electrician. Apprentices shall be under the direct supervision of a licensed electrician at all times.
- C. Any changes or deviations from the drawings and specifications must be accepted in

writing by the DEN Project Manager. All errors in installation shall be corrected at the expense of the Contractor. All specialties shall be installed as detailed on the drawings. Where details or specific installation requirements are not provided, manufacturer's recommendations shall be followed.

- D. Upon completion of Work, all equipment and materials shall be installed complete, thoroughly tested, checked, correctly adjusted, and left ready for intended use or operation. All Work shall be thoroughly cleaned and all residues shall be removed from surfaces. Exterior surfaces of all material and equipment shall be left in a perfect, unblemished condition.
- E. Contractor shall provide a complete installation, including all required labor, material, cartage, testing, insurance, permits, and taxes.

3.2 CHASES, OPENINGS, CUTTING AND PATCHING

- A. Carefully lay out all work in advance so as to eliminate where possible, cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings and roofs. Any damage to the building, structure, piping, ducts, equipment or any defaced finish shall be repaired by skilled mechanics of the trades involved at no additional cost to the Owner and to the satisfaction of the DEN Project Manager. Any necessary cutting, channeling, drilling or welding as required for the proper support, concealment, installation or anchoring of raceways, outlets, or other electrical equipment shall be performed in a careful manner, and shall be pre-approved by the DEN Project Manager.
- B. All openings made in fire-rated walls, floors, or ceilings shall be sealed and made tight in a manner to conform to the fire rating for the barrier penetrated. Reference specification Section 078413 "Penetration Firestopping" for additional information.
- C. All penetrations required through completed concrete construction shall be core drilled at minimum size required. All penetrations in concrete require an x-ray or ground penetrating radar to determine if the location is clear of reinforcing steel and embedded systems. Precautions shall be taken when drilling to prevent damage to structural concrete.

3.3 ELECTRICAL INSTALLATIONS

- A. Coordinate electrical systems, equipment, and material installation with other building components. If the Contractor furnishes equipment of a different size, the Contractor shall furnish and install the proper fuses, circuit breaker, disconnect switch, wire and conduit required for the equipment furnished, at no additional cost to the Owner, and as deemed acceptable by the DEN Project Manager.

3.4 PROGRESS OF WORK

- A. Coordinate the progress of electrical work to conform to the progress of the Work of the other trades. Complete the entire installation as soon as the condition of the sites will permit. Any cost resulting from defective or ill-timed work performed under Division 26 shall be borne by the Contractor.

3.5 ELECTRICAL COMPLETION

- A. Training of Operating and Maintenance Personnel: Furnish the services of a qualified representative of the supplier of each item or system itemized below who shall instruct specific personnel, as designated by the Owner, in the operation and maintenance of that item or system.
 - 1. Instruction shall be given when the particular system is complete, shall be of the number of hours indicated, and at the time requested by the Owner. A representative of the Contractor shall be present for all demonstrations.

Systems:	Hours of Instruction:

- B. Operating and Maintenance Manuals and Parts Lists: Deliver three (3) complete operating & maintenance manuals and parts lists in three-ring binders to the Owner at the time of the above required training. The information shall be provided on the manufacturer's original data sheets. Fully explain the contents of the manuals as part of required training and instruct the Owner's personnel in the correct procedure in obtaining service, both during and after the guarantee period.
 - 1. The operating and maintenance manuals and parts lists shall give complete information as to whom the Owner shall contact for service and parts. Include address and phone number. Furnish evidence that an authorized service organization regularly carries a complete stock of repair parts for these items (or systems), and that the organization is available for service. Service shall be furnished within 24 hours after requested.
- C. Operating and Acceptance Tests: Provide all labor, instruments, and equipment for the performance of tests as specified below and elsewhere in these specifications for all applicable equipment furnished and installed as part of this Contract. Submit three (3) copies of test reports to the DEN Project Manager for the DEN Project Manager's approval.
- D. Clean Up: Remove all materials, scrap, etc., relative to the electrical installation, and leave the premises and all equipment, lamps, fixtures, etc. in a clean, orderly condition. Clean all electrical equipment, such as switchboards, panel boards, luminaries etc. of construction dirt, dust, etc. and touch-up or repaint all scratches, blemishes, rust spots etc. to its original condition. Any costs to the Owner for cleanup of the site will be charged against the Contractor.

- E. Acceptance Demonstration: Upon completion of the Work, at a time to be designated by the DEN Project Manager, the Contractor shall demonstrate for the Owner the operation of the entire installation, including all systems provided or modified under this Contract.
- F. Final Acceptance by the Owner will not occur until all operating instructions are received and Owner's personnel have been thoroughly indoctrinated in the maintenance and operation of all equipment, as approved by DEN Project Manager.

PART 4 - MEASUREMENT

4.1 METHOD OF MEASUREMENT

- A. No separate measurement shall be made for work under this Section.

PART 5 - PAYMENT

5.1 METHOD OF PAYMENT

- A. No separate payment will be made for work under this Section. The cost of the work described in this Section shall be included in the Unit Item Contract price.

END OF SECTION **260400**

SECTION 260505 - SELECTIVE DEMOLITION FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 RELATED SECTIONS

- A. Section 011000 "Summary" for restrictions on the use of the premises, Owner-occupancy requirements, and phasing requirements.
- B. Section 024119 "Selective Demolition" for demolition and removal of selected site elements.
- C. Section 260400 "Basic Electrical Requirements."
- D. Section 311000 "Site Clearing" for site clearing and removal of above- and below-grade improvements.

1.3 ALTERNATES

- A. Refer to Division 01 Section 012300 "Alternates" for description of Work in this Section affected by Alternates.

PART 2 - PRODUCTS

2.1 EQUIPMENT

- A. Provide construction tools, equipment materials, and supplies of the type and quantities that will facilitate the timely execution of the work.

PART 3 - EXECUTION

3.1 PROCEDURES

- A. Existing electrical systems shall not be abandoned in place.

- B. No area; new, remodeled, or existing shall be without a fully operational electrical system, except for scheduled outages.
- C. The contractor shall remove, relocate or replace any electrical equipment or systems as required for installation of any structural, mechanical or plumbing equipment,
- D. Maintain all existing electrical, control, communication, and signaling systems to the extent required by the owner.
- E. Maintain all existing electrical, control, communication, and signaling systems to the extent required by the owner.
- F. Where remodel or demolition interferes with circuits outside of the work area, schedule outages to rework the circuits as required.
- G. All items that are removed and not designated by the Project Manager to be used or turned over to the owner shall be removed from the airport.

PART 4 - MEASUREMENT

4.1 METHOD OF MEASUREMENT

- A. No separate measurement shall be made for work under this Section.

PART 5 - PAYMENT

5.1 METHOD OF PAYMENT

- A. No separate payment will be made for work under this Section. The cost of the work described in this Section shall be included in the Unit Item Contract price.

END OF SECTION 260505

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
- B. Related Sections include the following:
 - 1. Division 26 Section "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.
 - 2. Division 26 Section "Undercarpet Electrical Power Cables" for flat cables for undercarpet installations.
 - 3. Division 27 Section "Communications Horizontal Cabling" for cabling used for voice and data circuits.
- C. Alternates: Refer to Division 01 Section 012300 "Alternates" for description of Work in this Section affected by Alternates.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Include data substantiating that materials comply with requirements.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. As-Built Plans: Submit complete as-built plans of all Work, including interface with other Work, in accordance with requirements as specified in Section 013300 "Submittal Procedures".

1.7 QUALITY ASSURANCE

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

1.8 CONSTRUCTION WASTE MANAGEMENT

- A. Construction waste shall be managed in accordance with provisions of Section 017419 "Construction Waste Management and Disposal". Documentation shall be submitted to satisfy the requirements of that Section.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Insulated Wire Corp.; a Leviton Company.
 - 2. General Cable Corporation.
 - 3. Southwire Company.
 - 4. Encore Wire Corp.
 - 5. Cerro Wire and Cable Company.
 - 6. CME Wire.
 - 7. Coleman Cable Inc.
 - 8. or approved equal.
- B. All conductors shall be copper.

- C. AC cable and Modular wiring are not permitted.
- D. MC Cable: Comply with NEMA WC 70. Provide internal equipment grounding conductor throughout.
- E. Copper Conductors: Comply with NEMA WC 70.
- F. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN and XHHW.
- G. Remote Control and Signal Cable
 - 1. Control Cable for Class 1 Remote Control and Signal Circuits: Copper conductor, 600 volt insulation, rated at 60 deg C, individual conductors twisted together, shielded, and covered with a PVC jacket.
 - 2. Control Cable for Class 2 or Class 3 Remote Control and Signal Circuits: Copper conductor, individual conductors twisted together, shielded, and covered with a PVC jacket; UL listed.

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Hubbell Power Systems, Inc.
 - 3. O-Z/Gedney; EGS Electrical Group LLC.
 - 4. 3M; Electrical Products Division.
 - 5. Tyco Electronics Corp.
 - 6. Ideal.
 - 7. or approved equal.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger. With the exception of number 6 AWG soft-drawn, solid, bare copper ground wire as indicated on the plans.
- B. Branch Circuits: Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger, except for connection to vibrating equipment then stranded shall be used.

- C. Prohibited Cable Types: UF, NM, SE, AC.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Minimum wire size shall be based on the over current protection device and as governed by the NEC.
- B. Service Entrance: Type XHHW, single conductors in raceway.
- C. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- D. Feeders below Slabs-on-Grade, and Underground: Type THWN, single conductors in raceway.
- E. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THWN, single conductors in raceway.
- F. Class 1 Remote Control and Signal Circuits: Type THHN-THWN, in raceway or cable tray as applicable, or Copper conductor, 600 volt insulation, individual conductors twisted together, shielded, and covered with a PVC jacket.
- G. Class 2 Remote Control and Signal Circuits: Type THHN-THWN, in raceway or cable tray as applicable, or Copper conductor, individual conductors twisted together, shielded, and covered with a PVC jacket; UL listed.
- H. All power, control, data, communication and signal wire or cable shall be installed in an approved raceway.
- I. MC Cable is prohibited on this project:

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. All power, control, data, communication and signal wire or cable shall be installed in an approved raceway (raceway shall be defined as conduit or cable tray as applicable).
- B. Verify raceways are open, continuous and clear of debris before installing cables.
- C. Pull all conductors into a raceway at the same time. Use a listed wire pulling lubricant for pulling No. 4 AWG and larger wires.
- D. Completely and thoroughly swab raceway system before installing conductors for conduit in floors, concrete, or below grade.
- E. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed

manufacturer's recommended maximum pulling tensions and sidewall pressure values.

- F. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.
- G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- H. Pulling winches and other necessary pulling equipment shall be of adequate capacity to ensure a continuous pull on the cable. Strain gages shall be used to monitor the cable pulling tension.
- I. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- J. Neatly train wiring inside boxes, equipment, and panel boards. Make temporary connections to panel board devices with sufficient slack conductor to facilitate reconnections required for balancing loads between phases.
- K. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- L. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.
- M. Conductors shall not be pulled in concrete encased conduits before concrete is placed.
- N. For connection to vibrating equipment, stranded wire shall be used.
- O. All wiring shall be installed in a new approved raceway system. Existing conduits shall not be used unless approved by the DEN Project Manager.
- P. Where harmonic currents exist on feeders that supply panelboards that serve electronic equipment of 40 percent or more of the panelboards total ampacity, two (2) full size neutral conductors or a neutral conductor rated at 200 percent shall be provided to the panelboard being served. A neutral bus bar rated at 200 percent shall also be provided in the panelboard.
- Q. Shared Neutrals: Prohibited. A full-size neutral conductor shall be provided for each single-phase circuit.

3.4 CONNECTIONS

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

- B. Splice only in accessible junction and outlet boxes.
- C. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- D. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "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.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 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."

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Field inspection and testing will be performed under provisions of Division 01.
 - 2. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
 - a. Prior to energizing, all building service cables, feeders to and/or from transformers, switchboards and panel boards are to be tested with a 500-volt insulation megohm meter to determine insulation resistance levels. All field test data is to be recorded, corrected to a baseline temperature and furnished to the DEN Project Manager. A test is to include meggering for one minute between conductors and between each conductor and ground.

Cables are to be meggered after installation with cables disconnected at both ends. Insulation test values shall meet or exceed the values given below.

Conductor Size (AWG or KCMIL):	Resistance (Megohms-1,000ft):
12-8	200
6-2/0	100
3/0-750	100

3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
 - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice eleven (11) months after date of Substantial Completion.
 - b. Instrument: 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.
 4. Inspect wire and cable for physical damage and proper connection.
- B. Test and Inspection Reports: Prepare a written report to record the following:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Cables will be considered defective if they do not pass tests and inspections.

PART 4 - MEASUREMENT

4.1 METHOD OF MEASUREMENT

- A. No separate measurement shall be made for work under this Section.

PART 5 - PAYMENT

5.1 PAYMENT

- A. No separate payment will be made for work under this Section. The cost of the work described in this Section shall be included in the Unit Item Contract price.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes: Grounding systems and equipment.
- B. Section includes grounding systems and equipment, plus the following special applications:
 - 1. Service equipment grounding.
 - 2. Underground distribution grounding.
 - 3. Ground bonding at handholes.
- C. Alternates: Refer to Division 01 Section 012300 "Alternates" for description of Work in this Section affected by alternates.

1.3 SYSTEM DESCRIPTION

- A. Ground the electrical service system neutral at service entrance equipment to the metallic water pipe service on building side only and to supplementary grounding electrodes, as required by the contract documents and as required by the NEC.
- B. External (underground) metal pipes, water, gas, fuel, drain/sewer etc., are not available for electrical grounding. This is due to extensive cathodic protection and isolation joints of all underground metal pipes at DEN. These systems shall be bonded to the grounding system on the building side only.
- C. Ground each separately derived system neutral to nearest building steel and new ¾" x 10'-0" copper clad driven ground rods.
- D. An insulated equipment ground conductor shall be installed continuous from the main switchgear or service entrance to all branch panelboards, motor control centers, transformers and all motors. This conductor shall be bonded to the conduit and metal enclosures that it passes through utilizing bonding bushings and terminal devices.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Include data substantiating that materials comply with requirements.
- B. Shop Drawings:
 - 1. Submit shop drawings, coordination drawings, and product data in accordance with provisions of Division 1. Submit all required information under a given specification section together. Do not split out submittals under the same specification section.
 - a. Clearly mark each shop drawing as follows for purposes of identification:
 - 1) Shop Drawing
 - 2) Equipment Identification Used on Contract Drawings
 - 3) Date
 - 4) Name of Project
 - 5) Branch of Work
 - 6) Project Manager's Name
 - 7) Contractor's Name
 - b. Indicate layout of ground ring, location of system grounding electrode connections, and routing of grounding electrode conductors.
- C. Prior to submission, shop drawings, material lists and catalog cut sheets or manufacturer's printed data shall be thoroughly checked for compliance with contract requirements, compatibility with equipment being furnished by the Contractor or Owner, accuracy of dimensions, coordination with work of other trades, and conformance with sound and safe practice as to erection of installation. Each submittal shall bear Contractor's signed statement evidencing such checking.
- D. Clearly mark printed material, catalog cut sheets, pamphlets or specification sheets, and shop drawings with the same designation shown on the Contract Document schedules.

1.5 INFORMATIONAL SUBMITTALS

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

1.6 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. Instructions for periodic testing and inspection of grounding features at test wells and grounding connections for separately derived systems based on NFPA 70B fall of potential method.
 2. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
 3. Include recommended testing intervals.
- B. Record Documents
1. Maintain a contract set of electrical drawings and specifications at the site. Neatly mark all changes, discoveries, and deviations from the original drawings. Use a reproducible color that contrasts with the prints. This shall be a separate set of drawings, not used for construction purposes, and shall be updated daily as the job progresses and shall be made available for inspection by the DEN Project Manager at all times. Upon completion of the contract, this set of record drawings shall be delivered to the DEN Project Manager. Follow DEN BIM standards, to be furnished to the successful bidder. Record documents to be provided by the Contractor shall clearly and accurately show the following:
 - a. Provide horizontal and vertical dimensions for all raceway systems, size, and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
 - b. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 - c. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

1.8 CONSTRUCTION WASTE MANAGEMENT

- A. Construction waste shall be managed in accordance with provisions of Section 017419 "Construction Waste Management and Disposal". Documentation shall be submitted to

satisfy the requirements of that Section.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Codes.
- B. All ground wires shall be copper, sized according to the NEC or as shown on the drawings whichever is larger.
- C. 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 (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 stranded or No. 6 AWG, solid conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) 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.
- D. Bare Grounding Conductor and Conductor Protector for Wood Poles:
 - 1. No. 4 AWG minimum, soft-drawn copper.
 - 2. Conductor Protector: Half-round PVC or wood molding; if wood, use pressure-treated fir, cypress, or cedar.
- E. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) by 12 inches (300 mm) long, (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. Lexan or PVC, impulse tested at 5000 V.

2.2 CONNECTORS

- A. Listed and labeled by an NRTL 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, pressure type 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. Exothermic welded connections are required where grounding conductors connect to underground grounding conductors and to underground grounding electrodes, and for bonding to steel. All underground connections shall be exothermic welded.
- D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- E. Grounding Connection Accessories:
 1. Electrical insulating tape, heat-shrinkable insulating tubing, welding materials, bonding straps, as recommended by accessories manufacturers for type of service required.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad, 3/4 inch by 10 feet (19 mm by 3 m) in diameter and length.
- B. Ground Rods in manholes, ground rods shall be stainless steel 3/4-inch diameter and a minimum length of 10 feet.
- C. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
 1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
 2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 6 AWG and smaller, and stranded conductors for No. 4 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.
 1. Bury at least 36 inches (900 mm) below grade.
 2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
- 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. 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 UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Handholes: Install a driven ground rod through bottom of bottomless handhole, close to wall, and set rod depth so 4 inches (100 mm) will extend above gravel base. If handhole has a metallic cover, then bond a coiled number 6AWG stranded copper grounding conductor from ground rod to cover with enough length to allow cover to be removed.
- C. Pad-Mounted Transformers and Switches: Install a minimum of two ground rods a minimum of 8 feet apart for all disconnect switches and transformer locations bond all ground rods to equipment grounding terminals. Test grounding system, if ground resist is greater than 10ohms install additional ground rods and re-test.

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 1. Feeders and branch circuits.
 2. Lighting circuits.
 3. Receptacle circuits.
 4. Single-phase motor and appliance branch circuits.
 5. Three-phase motor and appliance branch circuits.
 6. Flexible raceway runs.
 7. Armored and metal-clad cable runs.
 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

10. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
- C. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch (6.3-by-100-by-300-mm) grounding bus.
 3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- D. Metal and Wood Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Bonding Common 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.
- C. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 2. For grounding electrode system, install at least two rods spaced at least 8'-0" from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.
1. Test Wells: Install at least one (1) 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.

- E. 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 bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- F. Grounding for Steel Building Structure: Install at a minimum of one driven ground rod at base of each bus shelter and bond to the shelter steel components as well as the ground bar in the shelter's panelboard. Provide an additional ground rod in the feeder splice box adjacent to the shelter and bond this rod to the ground bus in the shelter's panelboard.
- G. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.
 - 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's grounding grid or to grounding electrode external to concrete.

3.5 LABELING

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" Article for instruction signs.
- B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
 - 1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

- B. Tests and Inspections:
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.
 4. Measure ground resistance no fewer 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.
 5. Perform tests by fall-of-potential method according to IEEE 81.
 6. 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.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 2. Power Distribution Units or Panelboards Serving Electronic Equipment: 5 ohm(s).
 3. Substations and Pad-Mounted Equipment: 10 ohms.
 4. Handhole Grounds: 10 ohms.
 5. Ground resistance to earth of each ground rod: > 10 ohms.
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify DEN Electrical Engineer promptly and include recommendations to reduce ground resistance.

PART 4 - MEASUREMENT

4.1 METHOD OF MEASUREMENT

- A. No separate measurement shall be made for work under this Section.

PART 5 - PAYMENT

5.1 PAYMENT

- A. No separate payment will be made for work under this Section. The cost of the work described in this Section shall be included in the Unit Item Contract price.

END OF SECTION **260526**

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Innerduct
4. Metal wireways and auxiliary gutters.
5. Nonmetal wireways and auxiliary gutters.
6. Surface raceways.
7. Boxes, enclosures, and cabinets.
8. Handholes and boxes for exterior underground cabling.
9. Buried conduits in concrete encased duct banks.

B. Related Requirements:

1. Division 26 Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
2. Division 27 Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.
3. Division 28 Section 280528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.
4. Division 26 Section 260526 "Grounding and Bonding for Electrical Systems" for additional grounding and bonding requirements.

C. Prohibited Materials

1. Intermediate conduits.
2. Aluminum conduit.
3. Multi-conductor assemblies, unless written authorization is obtained from DEN Project Manager, or specifically allowed within specification.

D. Project Conditions

1. Verify locations of outlets and small pull-boxes prior to rough in.
2. Electrical and pull boxes are shown on Drawings in approximate locations unless dimensioned. Install at location required for box to serve intended purpose.

E. Alternates: Refer to Division 01 Section 012300 "Alternates" for description of Work in this Section affected by alternates.

1.3 DEFINITIONS

- A. GRC: Galvanized rigid steel conduit.
- B. RMC: Rigid Metallic Conduit.
- C. RNC: Rigid Nonmetallic Conduit.
- D. EMT: Electrical Metallic Conduit.
- E. FMC: Flexible Metallic Conduit.
- F. LFMC: Liquidtight Flexible Metallic Conduit.
- G. HDPE: High Density Polyethelene.
- H. FNC: Flexible Nonmetallic Conduit.
- I. ENT: Electrical non-metallic conduit.
- J. MC: Metal-clad cable.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
 1. Include data substantiating that materials comply with requirements.
- B. LEED Submittals (if required):
 1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
 2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations,

sections, and attachment details.

- D. Samples: Per request.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Structural members in paths of conduit groups with common supports.
 - 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- B. Qualification Data: For professional engineer.
- C. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.
- D. Source quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. As-Built Plans: Submit complete as-built plans of all Work, including interface with other Work, in accordance with requirements as specified in Section 013300 "Submittal Procedures".

1.7 CONSTRUCTION WASTE MANAGEMENT

- A. Construction waste shall be managed in accordance with provisions of Section 017419 "Construction Waste Management and Disposal". Documentation shall be submitted to satisfy the requirements of that Section.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 3. Anamet Electrical, Inc.
 - 4. Electri-Flex Company.

5. O-Z/Gedney; a brand of EGS Electrical Group.
 6. Picoma Industries, a subsidiary of Mueller Water Products, Inc.
 7. Republic Conduit.
 8. Robroy Industries.
 9. Southwire Company.
 10. Thomas & Betts Corporation.
 11. Western Tube and Conduit Corporation.
 12. Wheatland Tube Company; a division of John Maneely Company.
 13. or approved equal.
- B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
1. Comply with NEMA RN 1.
 2. Coating Thickness: 0.040 inch (1 mm), minimum.
- E. EMT: Galvanized tubing. Comply with ANSI C80.3 and UL 797.
- F. FMC: Comply with UL 1; zinc-coated steel.
- G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Set screw or compression.
 - c. Provide throated connectors where entering junction boxes.
 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
- I. Innerduct:
1. Inner duct, meeting or exceeding the following requirements, shall be used to partition conduit.
 - a. Melting point: 260 degrees F., minimum.

- b. Tensile yield strength: 3600 psi/sq. in., minimum
 - c. Brittleness temperature, maximum: -140 degrees F.
 - d. Heat distortion temperature: 170 degrees F minimum.
- J. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. AFC Cable Systems, Inc.
 - 2. Anamet Electrical, Inc.
 - 3. Arnco Corporation.
 - 4. CANTEX Inc.
 - 5. CertainTeed Corp.
 - 6. Condux International, Inc.
 - 7. Electri-Flex Company.
 - 8. Kraloy.
 - 9. Lamson & Sessions; Carlon Electrical Products.
 - 10. Niedax-Kleinhuis USA, Inc.
 - 11. RACO; a Hubbell company.
 - 12. Thomas & Betts Corporation.
 - 13. or approved equal.
- B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Rigid HDPE: Comply with UL 651A.
- E. Continuous HDPE: Comply with UL 651B.
- F. Coilable HDPE: Preassembled with conductors or cables and complying with ASTM D 3485.
- G. RTRC: Comply with UL 1684A and NEMA TC 14.
- H. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- I. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA

Method 24).

- J. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper B-Line, Inc.
 2. Hoffman; a Pentair company.
 3. Mono-Systems, Inc.
 4. Square D; a brand of Schneider Electric.
 5. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 6. or approved equal.
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1, Type 3R or Type 4x, and sized according to NFPA 70.
1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type or screw cover.
- E. Finish: Manufacturer's standard enamel finish.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Allied Moulded Products, Inc.
 2. Hoffman; a Pentair company.
 3. Lamson & Sessions; Carlon Electrical Products.
 4. Niedax-Kleinhuis USA, Inc.
 5. or approved equal.
- B. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended

location and application.

- C. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.
- D. Description: Schedule 40 PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.
- E. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.
- F. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- G. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by the DEN Project Manager.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mono-Systems, Inc.
 - b. Panduit Corp.
 - c. Wiremold / Legrand.
 - d. or approved equal.
- C. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by DEN Project Manager from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell Incorporated; Wiring Device-Kellems Division.

- b. Mono-Systems, Inc.
- c. Panduit Corp.
- d. Wiremold / Legrand.
- e. or approved equal.

2.6 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Adalet.
 2. Cooper Technologies Company; Cooper Crouse-Hinds.
 3. EGS/Appleton Electric.
 4. Erickson Electrical Equipment Company.
 5. FSR Inc.
 6. Hoffman; a Pentair company.
 7. Hubbell Incorporated; Killark Division.
 8. Kraloy.
 9. Milbank Manufacturing Co.
 10. Mono-Systems, Inc.
 11. O-Z/Gedney; a brand of EGS Electrical Group.
 12. RACO; a Hubbell Company.
 13. Robroy Industries.
 14. Spring City Electrical Manufacturing Company.
 15. Stahlin Non-Metallic Enclosures; a division of Robroy Industries.
 16. Thomas & Betts Corporation.
 17. Wiremold / Legrand.
 18. or approved equal.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Galvanized steel. Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover. Provide threaded hubs.
- E. Nonmetallic Outlet and Device Boxes: Prohibited, unless specifically allowed in writing by the DEN Project Manager.
- F. Metal Floor Boxes:
 1. Material: Cast metal.
 2. Type: Fully adjustable.
 3. Shape: Rectangular.
 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and

application.

- G. Nonmetallic Floor Boxes: Prohibited, unless specifically allowed by the DEN Project Manager.
 - 1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- H. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.
- I. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb (32 kg).
 - 1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- J. Small Sheet Metal Pull and Junction Boxes: Galvanized steel. NEMA OS 1.
- K. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized with gasketed cover.
- L. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- M. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep) or as approved by DEN Project Manager.
- N. Gangable boxes are allowed.
- O. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R or Type 4x as appropriate, with continuous-hinge cover with flush latch unless otherwise indicated. Screw cover enclosures: VL50 & NEMA 1.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Plastic or Fiberglass.
 - 3. Interior Panels: Steel; 14 gage steel, 12 gage if floor mounted, all sides finished with manufacturer's standard enamel, white.
 - 4. Large Pull Boxes: Boxes larger than 100 cubic inches in volume or 12 inches in any dimension.
 - a. Interior Dry Locations: Use hinged or screw covered enclosure.
 - b. Interior damp or wet locations: Use nema 3R hinged cover boxes.
- P. Cabinets:

1. NEMA 250, Type 3R galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel, gray.
2. Cabinet Fronts: Steel, flush or surface type as indicated, with concealed trim clamps, concealed hinge and flush lock keyed to match branch circuit panelboard; finish in gray baked enamel.
3. Provide 3/4-inch thick fire retardant plywood backboard or galvanized steel back plate painted matte white, for mounting terminal blocks.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
7. Fabrication:
 - a. Shop assemble enclosures and cabinets housing terminal blocks or electrical components in accordance with ANSI/NEMA ICS 6.
 - b. Provide knockouts on enclosures.
 - c. Provide protective pocket inside front cover with schematic diagram, connection diagram, and layout drawing of control wiring and components within enclosure.

Q. Terminal blocks and accessories:

1. All terminal Blocks: ANSI/NEMA ICS 4; UL listed.
2. Power Terminals: Unit construction type, closed-back type, with tubular pressure screw terminals, rated 600 volts.
3. Signal and Control Terminals: Modular construction type, channel mounted; tubular pressure screw terminals, rated 300 volts.
4. Power and signal/control wiring will use separate terminal blocks.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete or stainless steel Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.

- c. CDR Systems Corporation; Hubbell Power Systems.
 - d. NewBasis.
 - e. Oldcastle Precast, Inc.; Christy Concrete Products.
 - f. Synertech Moulded Products; a division of Oldcastle Precast, Inc.
 - g. or approved equal.
 2. Standard: Comply with SCTE 77.
 3. Configuration: Designed for flush burial with **[open] [closed] [integral closed]** bottom unless otherwise indicated.
 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 6. Cover Legend: Molded lettering, ["**ELECTRIC.**"] **<Insert legend>**.
 7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 8. Handholes 24 Inches Wide by 36 Inches Long (600 mm Wide by 900 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.
- C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete or stainless steel.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation; Hubbell Power Systems.
 - d. NewBasis.
 - e. Nordic Fiberglass, Inc.
 - f. Oldcastle Precast, Inc.; Christy Concrete Products.
 - g. Synertech Moulded Products; a division of Oldcastle Precast, Inc.
 - h. or approved equal.
 2. Standard: Comply with SCTE 77.
 3. Color of Frame and Cover: Gray.
 4. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
 5. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 6. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 7. Cover Legend: Molded lettering, "ELECTRIC." or "COMMUNICATIONS."
 8. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 9. Handholes 24 Inches Wide by 36 Inches Long (600 mm Wide by 900 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.8 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Tests of materials shall be performed by an independent testing agency.
 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Raceways shall not be installed in stairways or on the exterior of any building, unless specifically allowed by DEN Project Manager.
- B. Outdoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed Conduit: RMC.
 2. Concealed Conduit, Aboveground: RMC.
 3. Underground Conduit: Encased in concrete per Section 260543, "Underground Ducts and Raceways for Electrical Systems."
 - a. Direct buried conduits are not allowed unless specifically allowed by the DEN Project Manager.
 4. Exposed Conduit in Parking Garages or other covered structures open to environment:
 - a. Below 8'-0" AFF or within 10'-0" of extent of covered area: Galvanized RMC.
 - b. Above 8'-0" AFF and more than 10'-0" from extent of covered area: EMT with compression-type weatherproof/rain-tight connectors.
 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 6. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R Type 4.
- C. Indoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: GRC . Raceway locations

include the following:

- a. Loading dock.
 - b. Baggage tunnels
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 6. Wet Locations: GRC.
 7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

D. CONDUIT INSTALLATION SCHEDULE

1. Underground Installations More Than Five Feet from Foundation Wall: Polyvinyl Chloride (PVC) conduit Schedule 40. All bends greater than 45 degrees in non-metallic conduit shall be galvanized rigid steel conduit with a factory coating of polyvinyl chloride (PVC).
2. Installation in Concrete Slab: Not allowed.
 - a. All buried conduits containing cabling shall be installed in concrete encased duct banks.
3. In Slab Above Grade: Not allowed.
4. Wet Interior Locations: Rigid steel.
5. Concealed Dry Interior Locations: Electrical metallic tubing.
6. In Existing Walls of Existing Structure: Electrical metallic tubing or MC Cable.

E. Minimum Raceway Size: 3/4-inch (19-mm) trade size.

F. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use setscrew, or compression, steel fittings. Comply with NEMA FB 2.10.
 - a. Setscrew fittings to be used for indoor applications in dry locations only.
 - b. Compression fittings may be used in indoor or outdoor locations for damp or wet locations.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

- G. Install surface raceways only where indicated on Drawings.
- H. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).
- I. Unless otherwise indicated and where not otherwise restricted, use the conduit type indicated for the specified applications. Where more than one listed application applies, comply with the most restrictive requirements. Where conduit type for a particular application is not specified, use Galvanized Rigid Conduit.

3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Maintain a minimum of 6 inches (150 mm) between conduit and other piping. Maintain twelve inches (12") clearance between conduit and a heat source such as heating pipes, exhaust flues and heating appliances. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 24 inches (610 mm) of changes in direction.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines. Use conduit bodies to make changes in direction around beams or columns.
- H. Support conduit within 24 inches (610 mm) of enclosures to which attached. Support conduit at a maximum of 8 feet on center, within two (2) feet of a box or fitting.
- I. Use only factory cast hubs for fastening conduit to cast boxes and use steel or malleable iron hubs for fastening conduit to sheet metal boxes or equipment in damp or wet locations.
- J. Avoid moisture traps where possible; where unavoidable, provide junction box with drain fitting at conduit low point.
- K. Use suitable conduit caps to protect installed conduit against entrance of dirt and moisture during construction.

- L. Use PVC-coated rigid steel factory elbows for bends greater than 45 degrees in plastic conduit runs.
- M. Exposed conduits subject to physical damage to be rigid steel to 6'-0" above floor, deck or grating except in electrical, communications and mechanical rooms.
- N. Conduit stubbed up shall be two inches above slab or housekeeping pad and the empty conduits shall be capped. Under freestanding equipment conduits with conductors shall be sealed with duct seal.
- O. Flexible steel conduit runs shall not exceed 6' in length when connecting equipment, 6' in length when connecting light fixtures or when fished in hollow spaces with written approval by DEN Project Manager and shall contain a grounding conductor.
- P. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT or RMC for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- Q. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- R. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
- S. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- T. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- U. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- V. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- W. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- X. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 160-lb (72-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above

grade alongside raceways in use.

Y. Surface Raceways:

1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

Z. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

AA. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

BB. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

CC. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of

- straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
 6. Provide external bonding jumper for all expansion fittings.
- DD. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors. All vibrating equipment such as motors, transformers, and generators shall be connected with flexible steel conduit, not to exceed six feet in length.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- EE. Size conduit for conductor type installed or for Type THHN conductors, whichever is larger.
- FF. Arrange conduit to maintain headroom and present a neat appearance. Certain existing conditions may allow a waiver to this item.
- GG. Arrange conduit supports to prevent distortion of alignment by wire pulling operations. Fasten conduit using galvanized straps, lay-in adjustable hangers, clevis hangers, or bolted split stamped galvanized hangers.
- HH. Group conduit in parallel runs where practical and use conduit rack constructed of steel channel with conduit straps or clamps. Provide space for 25 percent additional conduit.
- II. Do not support conduit from cable tray or cable tray supports.
- JJ. Flexible conduit shall not be less than one-half (1/2) inch except when supplied with lighting fixtures. MC Cable shall be allowed in lieu of flexible conduit for light fixtures in lengths of 6 feet or less.
- KK. When anchoring to a dual sheet metal pan deck and concrete, anchors of any type when placed from below the deck shall be placed only in the lower pan form. No anchors shall be installed in the upper (high) pan.
- LL. X-ray [or ground penetrating radar] studies shall be made of concrete floors, walls or CMU walls prior to drilling or cutting of concrete and submitted to the DEN Project Manager for review and approval.
- MM. Mount boxes at heights indicated on Drawings. Install boxes with height measured to

- center of box unless otherwise indicated. Coordinate mounting heights and locations of boxes or outlets so as not to be interfered with by grounding systems, electrical panels, or any other building accessory.
- NN. Coordinate installation of outlet or equipment boxes for systems or products furnished under other sections.
- OO. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- PP. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel. Provide minimum 8-inch separation.
- QQ. Locate boxes so that cover or plate will not span different building finishes.
- RR. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- SS. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- TT. Set metal floor boxes level and flush with finished floor surface.
- UU. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- VV. Install electrical boxes as shown on Drawings, and as required for equipment, terminal strips, splices, taps, wire pulling, equipment connections and compliance with regulatory requirements.
- WW. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6 inches from ceiling access panel or from removable recessed light fixture.
- XX. Align adjacent wall-mounted outlet boxes for switches, thermostats, and similar devices with each other.
- YY. Use adjustable steel channel fasteners or all thread for hanging ceiling outlet box, support box from structure.
- ZZ. Support boxes in the ceiling with ¼" threaded rod as a minimum.
- AAA. Use appropriate gang box where more than one device is mounted together.
- BBB. Use 4-inch square box with plaster ring for single device outlets.
- CCC. Use malleable iron outlet box when surface mounted: on exterior of building, in wet location or damp location.

- DDD. Minimum junction and pull box size 4-11/16" x 4-11/16" x 2-1/8".
- EEE. Minimum outlet box size 4" x 4" x 2-1/8" including feed through outlet boxes.
- FFF. Minimum junction box size for fire alarm pull stations, control module, monitor module, 4" x 4" x 2-1/8". Provide plaster ring at all pull station locations.
- GGG. Use flush mounting outlet boxes in finished areas.
- HHH. Install knockout closure in unused box openings.
- III. Install cabinets and enclosures plumb; anchor securely to wall and structural supports at each corner, minimum.
- JJJ. All floor-mounted equipment shall be on a 4" nominal concrete housekeeping pad.
- KKK. No cabinet shall be supported on slab or grade.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Refer to Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for underground conduit installation requirements.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Refer to Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for underground handhole and box installation requirements

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by

- manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

PART 4 - MEASUREMENT

4.1 METHOD OF MEASUREMENT

- A. No separate measurement shall be made for work under this Section.

PART 5 - PAYMENT

5.1 PAYMENT

- A. No separate payment will be made for work under this Section. The cost of the work described in this Section shall be included in the Unit Item Contract price.

END OF SECTION 260533

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Conduit, ducts, and duct accessories for direct-buried and concrete-encased conduits.
 - 2. Handholes and boxes.
- B. Related Sections:
 - 1. Section "033350 "Flowable Backfill Low-Strength Concrete" for flowable backfill concrete.
- C. Alternates: Refer to Division 01 Section 012300 "Alternates" for description of Work in this Section affected by alternates.

1.3 DEFINITIONS

- A. RNC: Rigid nonmetallic conduit.
- B. HDPE: High density polyethylene
- C. PVC: Poly-vinyl chloride

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Duct-bank materials, including separators and miscellaneous components.
 - 2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
 - 3. Accessories for handholes, boxes.

4. Warning tape.
5. Warning planks.
6. Include data substantiating that materials comply with requirements.

B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Reinforcement details.
3. Frame and cover design and manhole frame support rings.
4. Ladder details.
5. Grounding details.
6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
7. Joint details.

C. Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Cover design.
3. Grounding details.
4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

A. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer.

B. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C 858.

C. Qualification Data: For professional engineer and testing agency.

D. Source quality-control test reports.

E. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. As-Built Plans: Submit complete as-built plans of all Work, including interface with other Work, in accordance with requirements as specified in Section 013300 "Submittal Procedures".

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
- B. Comply with ANSI C2.
- C. Comply with NFPA 70.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
- B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
- C. Lift and support precast concrete units only at designated lifting or supporting points.

1.9 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Any power outages necessary to install or test electrical systems and/or equipment shall be coordinated with Denver International Airport Maintenance/Engineering. A written shutdown request form shall be submitted to and approved by the DEN Project Manager two (2) weeks prior to the shutdown.
 - 2. Do not proceed with interruption of electrical service without Owner's written permission.

1.10 COORDINATION

- A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the

field.

- B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by DEN Project Manager.

1.11 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.
- B. Furnish cable-support stanchions, arms, insulators and associated fasteners in quantities equal to 10 percent of quantity of each item installed.

1.12 CONSTRUCTION WASTE MANAGEMENT

- A. Construction waste shall be managed in accordance with provisions of Section 017419 "Construction Waste Management and Disposal". Documentation shall be submitted to satisfy the requirements of that Section.

PART 2 - PRODUCTS

2.1 CONDUIT

- A. Rigid Steel Conduit: Galvanized Rigid Conduit (GRC) with factory bonded 40 mil. PVC coating (inside and out). Comply with ANSI C80.1.
- B. Rigid metallic conduit used for elbows and sweeps shall be PVC coated (inside and out), schedule 40 galvanized rigid conduit bent to shape at the factory. All connections to Non-Metallic rigid conduits shall be made with threaded couplings.
- C. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following::

1. ARNCO Corp.
 2. Beck Manufacturing.
 3. Cantex, Inc.
 4. CertainTeed Corp.; Pipe & Plastics Group.
 5. Condux International, Inc.
 6. ElecSys, Inc.
 7. Electri-Flex Company.
 8. IPEX Inc.
 9. Lamson & Sessions; Carlon Electrical Products.
 10. Manhattan/CDT; a division of Cable Design Technologies.
 11. Spiraduct/AFC Cable Systems, Inc.
 12. or approved equal.
- B. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
- C. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type DB-60-PVC and Type DB-120-PVC, ASTM F 512, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
- D. Duct Accessories:
1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
 2. Inner-ducts shall be nominal 1-inch internal diameter with longitudinally fluted (finned) construction to reduce cable pulling friction. Inner-ducts shall be manufactured of high density polyethylene and provided in blue, orange and black. Inner-duct shall be installed in unbroken (no couplings) lengths between Underground Concrete Vaults and pull boxes.
 3. Pull Tape shall be $\frac{3}{4}$ " wide woven Aramid fiber with no more than 4% elongation at yield. Tape shall provide a tensile strength of 2500 lbs. Tape shall be provided with accurate sequential footage marks at one foot intervals.
 4. Flow able backfill shall be 60 to 100 psi, Designed in accordance with ASTM C 94 and ASTM D 4832. Reference Section 033350 "Flowable Backfill Low-Strength Concrete".
 5. Red concrete for encasement shall be 3,000 psi minimum, 28-day compressive strength and 3/8-inch maximum aggregate size. The color shall be Davis Color "Baja Red." Use Davis Color # 160 at a ratio of two (2) pounds powder dose for each sack of cement in the mix or equal as determined by the manufacturer and DEN Project Manager to achieve desired color.
 6. Warning Tape: Underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."
 7. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 76 mm) in size, manufactured from 6000-psi (41-MPa) concrete.
 - a. Color: as specified for encasement concrete above.

- b. Mark each plank with "ELECTRIC" in 2-inch (50-mm) high, 3/8-inch (10-mm) deep letters.
8. Mortar shall comply with ASTM C 270, Type M, except for quantities less than 2.0 cubic feet where packaged mix complying with ASTM C 387, Type M, may be used.
9. Steel bore casings shall be ASTM A/252 Grade 2
10. Counterpoise conductor shall be #6 bare hard drawn or soft drawn copper. Exothermic welds shall be utilized at all connections.

2.3 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Description: Comply with SCTE 77.

1. Color: Gray.
2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC." or "COMMUNICATIONS." As indicated for each service.
6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 24 inches wide by 36 inches long (600 mm wide by 900 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following::
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation.
 - d. NewBasis.
 - e. Hubbell Quazite
 - f. or approved equal.

C. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Christy Concrete Products.
 - d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.
 - e. Hubbell Quazite
 - f. or approved equal.

- D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carson Industries LLC.
 - b. Christy Concrete Products.
 - c. Nordic Fiberglass, Inc.
 - d. Hubbell Quazite
 - e. or approved equal.

- E. High-Density Plastic Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall polymer concrete.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carson Industries LLC.
 - b. Nordic Fiberglass, Inc.
 - c. PenCell Plastics.
 - d. Hubbell Quazite
 - e. or approved equal.

2.4 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.

- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 1. Tests of materials shall be performed by a independent testing agency.
 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or the manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 3. Testing machine pressure gages shall have current calibration certification

complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 UNDERGROUND DUCT APPLICATION

- A. Underground conduits shall be Poly-vinyl Chloride (PVC) schedule 40 or greater, or Galvanized Rigid Conduit (GRC) with factory bonded 40 mil. PVC coating.
- B. All underground duct banks inside and outside of the building shall be encased in red concrete, supported on listed conduit spacers every five (5) feet, with a minimum of three (3) inches of cover on all sides and two (2) inches between conduits at a minimum depth of 36 - inches from top of concrete encasement to finished grade. A 3" wide red metallized foil core detectable warning tape shall be placed over the duct bank at a depth not exceeding the manufacturer's recommendations.
 - 1. EXCEPTION: for this project, any conduit routed direct buried under existing or new parking lot concrete (including the new bus lanes) shall not be encase in red concrete.
 - 2. All areas outside of the Pikes Peak Parking Lot shall be open trench and the conduit(s) shall be encased in red concrete as described above.
- C. Concrete encased duct banks shall be utilized for all primary duct banks at DEN. Primary duct banks are considered those duct banks that form the main arteries of the DEN duct bank system and those serving any DEN owned facility or structure. Concrete encasement shall also be used on segments of direct buried duct bank that cross under paved roadways or other locations subject to vehicular traffic.
- D. Include a bare #2 copper ground conductor above conduits in all concrete encased duct banks.
- E. A 1-inch minimum size shall be used for underground conduit.
- F. The minimum size of any underground high voltage (above 1,000 volt) conduit shall be 4".
- G. A separate insulated ground wire shall be installed in each conduit. The ground wire shall be sized on the drawings or in accordance with NEC article 250.
- H. Ducts for Electrical Cables Over 600 V: RNC, NEMA Type EPC-80-PVC, in concrete-encased duct bank, unless otherwise indicated.
- A. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80-PVC, in concrete-encased duct bank, unless otherwise indicated..

- B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80-PVC, in direct-buried duct bank, unless otherwise indicated.
- C. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-80-PVC, in direct-buried duct bank, unless otherwise indicated.
- D. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank, unless otherwise indicated.
- E. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, installed in concrete-encased duct bank, unless otherwise indicated.
- F. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.
- G. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EB-20-PVC, in concrete-encased duct bank, unless otherwise indicated.
- H. Underground Ducts Crossing Driveways Roadways : RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete, unless otherwise indicated.
 - 1. Steel reinforced, concrete encased duct banks shall be utilized for all duct bank segments running under aprons, taxiways and other aircraft movement areas.

1.2 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:
 - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
 - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 22 structural load rating.
 - 3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 22 structural load rating.
 - 4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.

1.3 EARTHWORK

- A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use

heavy-duty, hydraulic-operated, compaction equipment.

- B. After installation of electrical work, backfill with flowable backfill to insure against the possibility of differential settling, then use flowable backfill to within 8 inches of final grade.
- C. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."
- E. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 32 Sections.

1.4 DUCT INSTALLATION

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
- B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches (1220 mm), vertically, and 9 feet (2.75 m) horizontally, unless otherwise indicated.
- C. All 90-degree elbow and risers to above grade installation shall be PVC coated GRC conduit.
 - 1. Transition from PVC/HDPE in trench to PVC coated GRC elbow and riser to the equipment above utilizing PVC coated GRC straight pipe.
 - 2. All fitting for PVC coated GRC shall have threaded connectors of the same type.
- D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- E. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) ducts, and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
 - 2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each

- conduit in the area of disturbed earth adjacent to manhole or handhole.
3. Grout end bells into structure walls from both sides to provide watertight entrances.
- F. Building Wall Penetrations: Make a transition from underground duct to rigid PVC coated steel conduit at least 10 feet (3 m) outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- G. Waterproofed Wall and Floor Penetrations: Install a watertight entrance-sealing device with sealing gland assembly on the inside. Anchor device into masonry construction with one or more integral flanges. Secure membrane waterproofing to the device to make permanently watertight.
- H. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.
- I. Pulling Cord: install pulling cord in ducts, including spares.
- J. When concrete encased duct bank or conduit penetrates a foundation wall of a manhole, hand hole, or large pull box, the encasement is required to be structurally attached to the wall. Furnish for approval a shop drawing showing the conduit terminations and how the concrete encasement will be tied into the structure.
- K. No conduits shall be encased in sidewalks, roadways, footings, grade beams and foundations except under special cases approved by the DEN Project Manager.
- L. Conduit penetrating a foundation wall or wall of a handhole or manhole shall be sleeved and continuous (without fittings) from the interior for a minimum of five (5') on the exterior. Conduit penetrating a footer or grade beam shall be sleeved and continuous for five feet (5') on either side of a footer or grade beam using a single ten foot piece of PVC coated GRC. Conduit penetrating a wall, footer or grade beam below grade shall be plastic coated rigid steel conduit. Conduit penetration of an exterior wall or wall of a handhole or manhole shall be made watertight.
- M. All G.R.C. entering or leaving manholes, hand holes or switch gear shall have a grounding bushing attached to the conduit and the ground wire attached to the bushing.
- N. Bell fittings shall be installed on all PVC conduits entering or leaving manholes or hand holes.
- O. All conduits in manholes and hand holes that contain conductors shall be sealed by duct seal and all empty conduits shall be sealed with an approved fitting.

- P. All cable shall be racked and supported in manholes.
- Q. Manholes and hand holes shall be water tight; joints in precast hand holes and manholes shall be filled with non-shrink mortar and finished flush with the adjoining surfaces after being made watertight.
- R. Concrete-Encased Ducts: Support ducts on duct separators.
1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches (150 mm) between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 2. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
 - a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations or use other specific measures to prevent expansion-contraction damage.
 - b. If more than one pour is necessary, terminate each pour in a vertical plane and install **3/4-inch (19-mm)** reinforcing rod dowels extending **18 inches (450 mm)** into concrete on both sides of joint near corners of envelope.
 3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
 4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
 5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
 6. Minimum Space between Ducts: 3 inches (75 mm) between ducts and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100 mm) between power and signal ducts.
 7. Depth: Install top of duct bank at least 36 inches below finished grade, unless otherwise indicated.
 8. Stub-Ups: Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.
 9. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

- a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.
10. Warning Tape: Bury warning tape approximately 12 inches (300 mm) above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches (75 mm) of the centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.
- S. Special Duct Bank Construction at Corners
1. The duct bank system at DEN supports copper cabling in sizes up to 1800 pairs. The pulling tension required to install these cable requires the use of winches and steel cables. Special provisions are required at corners to prevent these cables from sawing through the sidewall of the ducts.
 2. Corners in the duct bank system are required to be made with 4-inch galvanized rigid PVC coated conduit with a radius of at least nine (9) feet. Concrete encasement is required at corners to control stresses and movement in the duct system during cable installation.
- T. Duct Bank Provisions for Fiber Optic Cabling
1. Ducts designated for fiber-optic cabling shall be provided with three 1-inch inner-ducts. The three inner-ducts installed in each fiber duct shall be colored blue, orange and black.
- U. Direct-Buried Duct Banks:
1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
 2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches (150 mm) between tiers.
 3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6 inches (150 mm) in nominal diameter.
 4. Install backfill as specified in Division 31 Section "Earth Moving."
 5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches (100 mm) over ducts and hand tamp. Firmly tamp backfill around ducts to

provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

6. Install ducts with a minimum of 3 inches (75 mm) between ducts for like services and 6 inches (150 mm) between power and signal ducts.
7. Depth: Install top of duct bank at least 36 inches (900 mm) below finished grade, unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.
9. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
10. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches (75 mm) of concrete.
 - b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
11. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried ducts and duct banks, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional planks 12 inches (300 mm) apart, horizontally.

1.5 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.7-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
- D. Install handholes and boxes with bottom below the frost line, below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and

insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

- F. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in landscape and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
 - 1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Division 03 Section "Cast-in-Place Concrete," with a troweled finish.
 - 2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

1.6 GROUNDING

- A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

1.7 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
 - 2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
 - 3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.

1.8 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump. Remove foreign material.

PART 2 - MEASUREMENT

2.1 METHOD OF MEASUREMENT

- A. No separate measurement shall be made for work under this Section.

PART 3 - PAYMENT

3.1 PAYMENT

- A. No separate payment will be made for work under this Section. The cost of the work described in this Section shall be included in the Unit Item Contract price.

END OF SECTION 260543

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Identification for raceways.
 - 2. Identification of power and control cables.
 - 3. Identification for conductors.
 - 4. Underground-line warning tape.
 - 5. Warning labels and signs.
 - 6. Instruction signs.
 - 7. Equipment identification labels.
 - 8. Miscellaneous identification products.
- B. Alternates: Refer to Division 01 Section 012300 "Alternates" for description of Work in this Section affected by alternates.

1.3 ACTION SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
 - 1. Include data substantiating that materials comply with requirements.
- B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and IEEE C2.
- B. Comply with NFPA 70.

- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, 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.

1.6 CONSTRUCTION WASTE MANAGEMENT

- A. Construction waste shall be managed in accordance with provisions of Section 017419 "Construction Waste Management and Disposal". Documentation shall be submitted to satisfy the requirements of that Section.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

- 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. Pre-Printed Tags: Polyester tag, 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.2 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length

of color field for each raceway and cable size.

- B. Pre-Printed Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
- C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of cable it identifies and to stay in place by gripping action.
- D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.3 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- F. Pre-Printed Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.4 UNDERGROUND-LINE WARNING TAPE

- A. Tape:
 - 1. Recommended by manufacturer for the method of installation and suitable to

- identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
 3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE,.

2.5 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label: Machine printed, in black letters on white background, by thermal transfer or equivalent process. Minimum letter height shall be 1/4 inch (7 mm).
- B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black letters on white background, by thermal transfer or equivalent process. Minimum letter height shall be 1/4 inch (7 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.
- C. Self-Adhesive, Engraved, Laminated Acrylic, or Melamine Label: Adhesive backed, with black letters on white background. Minimum letter height shall be 1/4 inch (7 mm).
- D. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. Black letters on a white background. Minimum letter height shall be 1/4 inch (7 mm).
- E. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).
- F. Emergency Equipment labels shall be white letters on red background.
- G. Provide nameplates with a minimum letter height as indicated below. Examples are given below for the size of letters to use for a given application and this not a list of the equipment to be identified. All equipment is required to be identified.
 1. For equipment designation: switchboards and motor control centers: 1/2 inch, panel boards: 1/4 inch. For voltage, bus ampacity, feeder source, and circuit number: 1/8 inch.
 2. Individual circuit breakers and or motor starters in motor control centers: For equipment designation and section number: 1/4 inch, for load served and location of load: 1/8 inch. Inside the door, a typed label shall provide complete motor data including nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

3. Individual breakers in switchgears and switchboards: for breaker number (address number) and equipment designation; 1/4 inch, for breaker frame size and trip setting; 1/8 inch
4. Individual circuit breaker and spaces in panel boards: for numbers (section number) 1/4 inch.
5. Individual circuit breakers in distribution panel boards: 1/4 inch for panel being fed and 1/8 inch for its location.
6. Transformers: 1/4 inch for equipment designation and size; 1/8 inch for primary and secondary voltages, primary source and circuit number, secondary load and its location.
7. Individual remote indicating lights, meters, instruments, and control switches: 1/8 inch, indicate unit, equipment, or fire detector being monitored and condition indicated by illumination.
8. Individual switches and pilots: 1/8 inch, identify mechanical unit being served.
9. Disconnects, relay panels, lighting contactors: 1/4 inch for voltage and source circuit number.

2.6 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
 1. Minimum Width: 1/8 inch (3 mm).
 2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
- 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 (5 mm).
 2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. 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. 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.
- G. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.
- H. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

- A. Wire and Cable Marker:
 - 1. For wire/cables smaller than No. 2/0 use manufacturer's standard cable/conductor markers of wrap-around, pre-numbered plastic coated type are to be used and numbered to show circuit identification.
 - 2. For cables No. 4 AWG and larger heat shrink sleeving is to be used for phase color-coding.
- B. Cable/Conductor Identification:
 - 1. The application of cable/conductor identification, with circuit number, on each wire / cable in each box/enclosure/cabinet is required. The identification shall match the marking system used in panel boards, shop drawings, and contract documents.
 - a. Provide labels on all wires, including in boxes where wires are pulled through but not terminated, such as junction boxes.

- C. Accessible Raceways, 600 V or Less, for Service, Feeder, and Branch Circuits More Than A, and V to ground: Identify with self-adhesive vinyl label self-adhesive vinyl tape applied in bands. Install labels at maximum intervals.
- D. Junction and Pull Box ID: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
1. Emergency Work: EM.
 2. Power.
 3. Uninterruptible Power Supply: UPS.
 4. Fiber Optics: FO.
 5. Closed Circuit Television: CCTV.
 6. Paging System: PA.
 7. Radio Frequency: RF.
 8. Fire Alarm: FA.
 9. Temperature Control: TC.
- E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
1. Color-Coding for Phase Identification, 600 V or Less: Use colors listed below for branch-circuit conductors.
 - a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
 - b. Colors for 208/120-V 3-Phase Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - 4) Neutral: White
 - 5) Ground: Green
 - 6) Isolated Ground: Green with a yellow tracer
 - c. Colors for 120/208-V 1-Phase Circuits:
 - 1) Phase L1: Black.
 - 2) Phase L2: Red.
 - 3) Neutral: White
 - 4) Ground: Green
 - 5) Isolated Ground: Green with a yellow tracer
 - d. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.

- 4) Neutral: Gray
 - 5) Ground: Green
 - 6) Isolated Ground: Green with a yellow tracer
- e. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- F. Install instructional sign including the color-code for conductors using adhesive-film-type labels.
- G. Conductors to Be Extended in the Future: Attach write-on tags marker tape to conductors and list source.
- H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions and terminals. 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 the Operation and Maintenance Manual.
- I. Locations of Underground Lines: Identify with underground-line detectable warning tape for power, lighting, communication, and control wiring and optical fiber cable.
1. Install underground-line detectable line marker for encased duct bank, direct-buried cables, and cables in raceway.
- J. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
 - a. Indoor Equipment: Mechanically fastened, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch (13-mm) high letters on 1-1/2-inch (38-mm) high label; where two lines of text are required, use labels 2 inches (50 mm) high. Use black lettering on white field for normal and white letters on a red field for emergency. Provide text matching terminology and numbering of the contract documents and shop drawings. The sign shall include unit designation, source circuit number, circuit voltage, and other data

specifically indicated. Also, the sign shall indicate normal source circuit number ("Fed from . . .") and emergency source circuit number when the equipment is a transfer switch or fed directly from a transfer switch.

- b. Outdoor Equipment: Engraved, laminated acrylic or melamine label Stenciled legend 4 inches (100 mm) high.
- c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
- d. Fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:

- a. Panelboards: include main bus ampacity on sign. Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be engraved, laminated acrylic or melamine label screw attached to cover.
- b. Enclosures and electrical cabinets.
- c. Access doors and panels for concealed electrical items.
- d. Switchgear.
- e. Switchboards.
- f. Disconnect switch.
- g. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
- h. Substations.
- i. Emergency system boxes and enclosures.
- j. Motor-control centers.
- k. Enclosed switches.
- l. Selector switches, indicating lights. (Circuit number and voltage not required on sign).
- m. Enclosed circuit breakers.
- n. Enclosed controllers.
- o. Variable-speed controllers.
- p. Push-button stations.
- q. Power transfer equipment.
- r. Contactors.
- s. Remote-controlled switches, dimmer modules, and control devices.
- t. Battery-inverter units.
- u. Battery racks.
- v. Power-generating units.
- w. Monitoring and control equipment.
- x. UPS equipment.
- y. Telephone cabinets and switching equipment. (Circuit number and voltage not required on sign.)
- z. Fire alarm panels.
- aa. Security monitoring master station.
- bb. Relays
- cc. Lighting contactors

- dd. Individual distribution circuit breakers
- ee. >.

- 3. All panel boards shall have a typed panel schedule indicating the date, contractor, type of equipment served, and its location.

3.3 EQUIPMENT NAMING

- A. Electrical Panels shall be named according to the panel names indicated on the drawings.
- B. Naming Disconnects and Transformers
 - 1. Disconnects shall have the same as the equipment they serve.
 - 2. Transformers shall have the same name as the low-voltage panel they supply power to with the extension of -X

PART 4 - MEASUREMENT

4.1 METHOD OF MEASUREMENT

- A. No separate measurement shall be made for work under this Section.

PART 5 - PAYMENT

5.1 PAYMENT

- A. No separate payment will be made for work under this Section. The cost of the work described in this Section shall be included in the Unit Item Contract price.

END OF SECTION 260553

SECTION 260583 - ELECTRICAL CONNECTIONS FOR EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Electrical connections to equipment specified under other Sections or furnished by the Owner.
- B. Applications of electrical power, control and monitoring connections specified in this section include the following:
 - 1. From electrical source to motor starters.
 - 2. From motor starters to motors.
 - 3. To lighting fixtures and wiring devices.
 - 4. To converters, rectifiers, transformers, inverters, switchgear, switchboards, panel boards, generators and similar equipment.
 - 5. To grounds including ground electrode connections.
 - 6. Equipment furnished in other Divisions (unless indicated otherwise).
 - 7. Junction boxes and disconnect switches required for connecting motors and other electrical units of equipment are specified in applicable Division 26 sections, and are criteria of this Section.

- C. Related requirements:

- 1. Section 260519 "Low-Voltage Electrical Power Conductors and Cables".

- D. Alternates: Refer to Division 01 Section 012300 "Alternates" for description of Work in this Section affected by Alternates.

1.3 ACTION SUBMITTALS

- A. The following data shall be submitted in accordance with Sections 013300 "Submittal Procedures" required prior to starting installation:
 - 1. Product Data: Manufacturer's data on electrical connections for equipment products and materials.

- a. Include data substantiating that materials comply with requirements.
2. Complete wiring diagrams and/or shop drawings for installation purposes shall be furnished under the Mechanical or other Divisions, as required by DEN Project Manager, prior to installation.

1.4 CLOSEOUT SUBMITTALS

- A. As-Built Plans: Submit complete as-built plans of all Work, including interface with other Work, in accordance with requirements as specified in Section 013300 "Submittal Procedures".

1.5 QUALITY ASSURANCE

- A. Products, materials, equipment and systems shall comply with the following Codes and Standards:
 1. NFPA Compliance: NFPA 70, "National Electrical Code (NEC)" as adopted and amended by the Denver Building Code and as applicable to products used and the installation of electrical power connections (terminals and splices), junction boxes, motor starters and disconnect switches.
 2. IEEE Compliance: Std. 241, "IEEE Recommended Practice for Electric Power Systems in Commercial Buildings" pertaining to connections and terminations.
 3. ANSI Compliance: Applicable requirements of ANSI/NEMA and ANSI/EIA standards pertaining to products and installation of electrical connections for equipment.
 4. UL Compliance: UL Std. 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors" including, but not limited to, tightening of electrical connectors to torque values indicated. Electrical connection products and materials are to be UL-listed and labeled.

1.6 CONSTRUCTION WASTE MANAGEMENT

- A. Construction waste shall be managed in accordance with provisions of Section 017419 "Construction Waste Management and Disposal". Documentation shall be submitted to satisfy the requirements of that Section.

PART 2 - PRODUCTS

2.1 MATERIALS AND COMPONENTS

- A. Products shall be as specified in other Sections of this Division.
- B. General: Each electrical connection shall be a complete assembly of materials,

including but not necessarily limited to, pressure connectors, terminals (lugs), electrical insulating tape, heat-shrinkable insulating tubing, cable ties, stress cones, splice kits, termination kits, solder less wire nuts, and other items and accessories as needed to complete splices and terminations as required.

1. Connectors and Terminals: Electrical connectors and terminals shall mate and match, including sizes and ratings, with equipment terminals that are recommended by equipment manufacturer for intended applications.
2. Electrical Connection Accessories: Electrical insulating tape, heat-shrinkable insulating tubing and boots, stress cones, splice kits, termination kits, wire nuts and cable ties as recommended for use by accessories manufacturers for type of services required.
3. All connections installed in below grade splice boxes shall be rated watertight, submersible URD pedestal insulated lug connector type with the number of poles as required by the number of connecting conductors per phase, neutral and ground conductors in each splice box (minimum of 3-poles).

2.2 MECHANICAL AND ELECTRICAL COORDINATION

- A. Responsibility: It is the contractor's responsibility to complete the EXHIBIT A SCHEDULE included at the end of this Section. Reference Section 019990 "Standard Forms". The Contractor shall include all costs and work associated with these items in his bid.
- B. Verify location, size, and characteristics of all mechanical equipment before installation of electric service. In all cases of the installation of heating, ventilating, air conditioning, plumbing, and other mechanical equipment, the Contractor is responsible for all revisions, changes, and modifications necessary to properly supply electric services to the equipment.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.2 PREPARATION

- A. Review equipment submittals prior to installation and electrical rough-in. Verify location, size, and type of connections. Coordinate details of equipment connections with supplier and installer.

3.3 INSTALLATION

- A. Use wire and cable with insulation suitable for temperatures encountered in heat-producing equipment.
- B. Make conduit connections to equipment using flexible conduit. Use liquid-tight flexible conduit in damp or wet locations. Length shall be six feet (6') maximum.
- C. Install pre-finished cord set where connection with attachment plug is indicated or specified, use attachment plug with suitable strain-relief clamps.
- D. Provide suitable strain-relief clamps for cord connections to outlet boxes and equipment connection boxes.
- E. Make wiring connections in control panel or in wiring compartment of pre-wired equipment in accordance with manufacturer's instructions. Provide interconnecting wiring as required for a complete operating system.
- F. Install disconnect switches, controllers, control stations, and control devices such as limit switches and temperature switches as required for a complete operating system. Connect with conduit and wiring as required for a complete operating system.

3.4 EQUIPMENT CONNECTION SCHEDULE

- A. Furnish, set in place, and wire, except as may be otherwise indicated, all heating, ventilating, air conditioning, plumbing, fire protection, and other motors and controls in accordance with the electrical/mechanical coordination schedule. The contractor shall carefully coordinate with work performed under the Mechanical and other Divisions if these specifications.
- B. All line and low voltage wiring shall be installed utilizing materials and methods as specified in the Division 26 of the technical specifications.
- C. Provide NEMA-rated motors and equipment suitable for operation on the voltage systems as designated below, with tolerances for the allowable voltage variations above and below the nominal:

1. Rated Motor Voltage:

Service Voltage and Phase:	1/3 HP and smaller 1-Phase:	1/2 HP and Larger 3-Phase:
120/208V, 3-Phase	115V	208V (only when 480V is not available)
277/480V, 3-Phase		460V

3.5 INSTALLATION OF ELECTRICAL CONNECTIONS

- A. Electrical connections shall be installed in accordance with equipment manufacturer's written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC and NECA's "Standard of Installation" to ensure that products fulfill requirements.
1. As a minimum: Each feeder circuit to panelboards, switchboards, motor control centers, transformers, and 480-volt (and higher) motor circuits shall have an insulated equipment ground conductor.
 2. All medium voltage splices and terminations are to be made by a certified cable splicer/terminator.
 3. Electrical service and feeders are to be maintained to occupied areas and operational facilities when temporary service is required during interruptions to existing facilities. Momentary outages for replacing existing wiring systems with new wiring systems shall be scheduled. When the "cutting-over" has been successfully accomplished, temporary wiring is to be removed.
 4. Splices shall be covered with electrical insulating material equivalent to, or of greater insulation rating, than electrical insulation rating of those conductors being spliced.
 5. Cables and wires shall be trimmed as long as practicable and routing shall be arranged to facilitate inspection, testing, and maintenance.
 6. Connectors and terminals, including screws and bolts, shall be tightened in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Proper torquing tools, including torque screwdriver, beam-type torque wrench, and ratchet wrench with adjustable torque settings shall be used to comply with torquing values contained in UL 496A or the manufacturer's literature.
 7. Identification markers are to be fastened to each electrical power supply wire/cable conductor in accordance with Section 260553 "Identification for Electrical Systems".
 - a. Markers are to be affixed on each terminal conductor, as close as possible to the point of connection.

3.6 FIELD QUALITY CONTROL

- A. The correct direction of rotation of each motor is to be verified.
- B. Provide measured torquing value checklist with witness signature to DEN Project Manager.
- C. Perform infrared scanning of all splices and terminations as required in Section 260519 "Low-Voltage Electric Power Conductors and Cables".

PART 4 - MEASUREMENT

4.1 MEASUREMENT

- A. No separate measurement will be made for the work specified in this Section.

PART 5 - PAYMENT

5.1 PAYMENT

- A. No separate payment will be made for work specified in this Section, but shall be included in the Contract Unit Item Bid Price for Division 16 - Electrical, which price shall include all necessary and incidental material and work thereto.

END OF SECTION 260583

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.
 - 3. Load centers.
 - 4. Electronic-grade panelboards.
- B. Alternates: Refer to Division 01 Section 012300 "Alternates" for description of Work in this Section affected by alternates.

1.3 DEFINITIONS

- A. SVR: Suppressed voltage rating.
- B. TVSS: Transient voltage surge suppressor.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - 1. The term "withstand" means, "The unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic even."

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

1. Include data substantiating that materials comply with requirements.
- B. Shop Drawings: For each panelboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 3. Detail bus configuration, current, and voltage ratings.
 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 5. Include evidence of NRTL listing for series rating of installed devices.
 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 7. Include wiring diagrams for power, signal, and control wiring.
 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
- 1.6 INFORMATIONAL SUBMITTALS
- A. Qualification Data: For qualified testing agency.
- B. Field Quality-Control Reports:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- C. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.
- 1.7 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For panelboards and components 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 written instructions for testing and adjusting overcurrent protective devices.
 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.
- B. As-Built Plans: Submit complete as-built plans of all Work, including interface with other Work, in accordance with requirements as specified in Section 013300 "Submittal Procedures".

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Keys: Two (2) spares for each type of panelboard cabinet lock.
 - 2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two (2) spares for each panelboard.
 - 3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.9 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NEMA PB 1.
- F. Comply with NFPA 70.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.11 PROJECT CONDITIONS

- A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding minus 30 deg F (minus 35 deg C) to plus 120 deg F (plus 49 deg C).
 - b. Altitude: 5500 feet (1677 m), not exceeding 6600 feet (2000 m).
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
1. Ambient temperatures within limits specified.
 2. Altitude: 5500 feet, not exceeding 6600 feet (2000 m).
- C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Any power outages necessary to install or test electrical systems and/or equipment shall be coordinated with Denver International Airport Maintenance/Engineering. A written shutdown request form shall be submitted to and approved by the DEN Project Manager two (2) weeks prior to the shutdown.
 2. Do not proceed with interruption of electric service without DEN Project Manager's written permission.
 3. Comply with NFPA 70E.

1.12 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.13 WARRANTY

- A. Special Warranty: for Surge Suppression Devices Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Minimum five (5) years from date of Substantial Completion.

1.14 CONSTRUCTION WASTE MANAGEMENT

- A. Construction waste shall be managed in accordance with provisions of Section 017419 "Construction Waste Management and Disposal". Documentation shall be submitted to satisfy the requirements of that Section.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section "Vibration and Seismic Controls for Electrical Systems."
- B. Enclosures: Surface-mounted cabinets.
 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 3R.
 - c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4>.
 - d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 6. Finishes:
 - a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
 7. Enclosures shall be at least 20 inches wide made from galvanized sheet steel in the sizes and NEMA types indicated, code gauge, minimum 16 gauge thickness
 8. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
- C. In all cases where the conductor to be connected to the busbar is 1/0 or larger cable,

the connection shall be made with a 2-hole compression lug. Torque all lug, wire and bus terminations to the manufacturers recommendation using a micrometer type wrench.

- D. Incoming Mains Location: Top and bottom.
- E. Phase, Neutral, and Ground Buses:
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 - 3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 - 4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads, with a corresponding increase in the size of the grounded conductor back to the supply.
 - 5. Split Bus: Vertical buses divided into individual vertical sections.
- F. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Main and Neutral Lugs: Mechanical type.
 - 3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
 - 4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - 5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - 6. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - 7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- G. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
- H. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.
- J. Breakers shall have built-in test points for testing long delay, and instantaneous functions of the breaker by means of a 120 volt operated test kit.
- K. General Requirements for Branch Circuit Panelboards:
 - 1. Bolt-on type, heavy-duty, quick-make, quick-break, single- and multi-pole circuit breakers, of the types specified herein, shall be provided for each circuit with

- toggle handles that indicate when unit has tripped.
2. Circuit breakers shall be thermal magnetic type with common type handle for all multiple pole circuit breakers. Circuit breakers shall be minimum 100-ampere frame and up through 100-ampere trip sizes shall take up the same pole spacing. Circuit breakers shall be UL listed as Type SWD for lighting circuits.
 - a. Circuit breaker handle locks shall be provided for all circuits that supply exit signs, emergency lights, energy management and control system (EMCS) panels and fire alarm panels.
 - b. Main circuit breaker, when shown, shall be vertical mounted top or bottom as required. Chassis mounted reverse fed main circuit breaker is not acceptable.
 3. Circuit breakers shall have a minimum interrupting rating of 10,000 amperes symmetrical at 240 volts and 14,000 amperes symmetrical at 480 volts.

2.2 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Match existing manufacturer in the immediate area, if applicable. Subject to compliance with requirements, provide products by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Square D; a brand of Schneider Electric.
 4. or approved equal.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.
- D. Mains: Circuit breaker.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
- G. Branch Overcurrent Protective Devices: Fused switches.
- H. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
 1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

2. External Control-Power Source: 120-V branch circuit.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Square D; a brand of Schneider Electric.
 4. or approved equal.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
 1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
 2. External Control-Power Source: 120-V branch circuit.
- F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- G. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Square D; a brand of Schneider Electric.
 4. or approved equal.
- B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with fully-rated interrupting capacity to meet available fault currents.
 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 600 A and below.

2. Breakers with frame sizes above 600 amperes shall be solid state trip, complete with built-in current transformers, solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings. Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed.
 3. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 4. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I2t response.
 5. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 6. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 8. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
 9. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in **[on]** **[off]** **[on or off]** position.
 - e. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
1. Fuses, and Spare-Fuse Cabinet: Comply with requirements specified in Division 26 Section "Fuses."
 2. Fused Switch Features and Accessories: Standard ampere ratings and number of poles.

2.5 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent

protective device test, inspection, maintenance, and operation.

- B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Equipment Mounting: Install panelboards on concrete bases, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Section 03300 "Cast-in-Place Concrete" and 033053 "Miscellaneous Cast-in-Place Concrete".
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
 - 2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to panelboards.
 - 5. Attach panelboard to the vertical finished or structural surface behind the panelboard.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- D. Comply with mounting and anchoring requirements specified in Section "Vibration and Seismic Controls for Electrical Systems."
- E. Mount top of trim 68 inches (1728 mm) above finished floor unless matching height of

existing equipment or approved otherwise. To fit inside the NEMA 4 enclosure.

- F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- G. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
- H. Install filler plates in unused spaces.
- I. Stub five 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub five 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
- J. Arrange conductors in gutters into groups and bundle and wrap with wire ties.
- K. Comply with NECA 1.

3.3 PANELBOARD SCHEDULE

- A. Panelboards shall be furnished and equipped as follows, except as otherwise specified:

Manufacturer:	120/208V:	277/480V:	600- 1200A:
Cutler Hammer	PRL-1	PRL-2	PRL-3 or 4
Square-D	NQOD	NEHB	I-LINE
GE	NLAB	NHB	CCB

Or approved equal by other manufacturer.

- B. Panelboards may contain not more than one subfeed breaker with ratings in excess of 100A, but less than 225A.
- C. Distribution panelboard shall be scheduled where more than one subfeed breaker rated in excess of 100A is required, and for any panelboard containing breakers with ratings of 225A or more.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Clearly identify the load on each circuit, equipment serviced and location. Revise directory to reflect circuiting changes required to balance phase loads. In all instances where a contractor installs or disconnects a circuit in any panel, a newly typed panel schedule shall be furnished.

The new or revised panel schedule shall have the date and Contractor's name typed at the top right hand corner. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections, preparing a written report for each including test results:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than sixty (60) days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard eleven (11) months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- F. Submit torque values for all connections with a torque schedule and witness signature.

3.6 ADJUSTING

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

3.7 PROTECTION

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

PART 4 - MEASUREMENT

4.1 METHOD OF MEASUREMENT

- A. No separate measurement shall be made for work under this Section.

PART 5 - PAYMENT

5.1 PAYMENT

- A. No separate payment will be made for work under this Section. The cost of the work described in this Section shall be included in the Unit Item Contract price.

END OF SECTION **262416**

SECTION 265600 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes general information related to providing and installing all exterior lighting systems throughout the project.
- B. Exterior Lighting Systems consisting of the following:
 - 1. Exterior Luminaires
 - 2. Light Sources
 - 3. Drivers
 - 4. Luminaire Supports
 - 5. Poles
- C. Products furnished but not installed under this Section
 - 1. Division 26 Section "Lighting Controls Devices": automatic control of lighting including photocells, occupancy and vacancy sensors, multi-pole lighting relays and contactors.
- D. Products furnished but not installed under this Section
 - 1. Division 26 Section "Lighting Controls": Central Dimming Controls and Networked Lighting Controls.
- E. Products installed but not furnished under this Section
 - 1. Division 26 Section "Interior Lighting"
- F. Alternates: Refer to Division 1 Section "Alternates" for description of Work in this Section affected by alternates.

1.2 DEFINITIONS

- A. CRI: Color-rendering index.
- B. CCT: Correlated Color Temperature.
- C. HID: High-intensity discharge.
- D. LER: Luminaire efficacy rating.

- E. Luminaire: Complete luminaire, including driver housing if provided.
- F. LED Light Source(s): Light Emitting Diode packages(s), module(s), and array(s).
- G. SSL: Solid State Lighting including light emitting diodes (LED) and Organic LED (OLED).
- H. Pole: Luminaire support structure, including tower used for large area illumination.
- I. Standard: Same definition as "Pole" above.
- J. NRTL: Nationally recognized testing laboratory.

1.3 SYSTEM DESCRIPTION

- A. Refer to Exterior Luminaire Schedule on plans for luminaire and pole descriptions.

1.4 PERFORMANCE REQUIREMENTS

- A. Refer to Exterior Luminaire Schedule on plans for specific requirements.

1.5 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

- A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4.
- B. Live Load: Single load of 500 lbf (2224 N), distributed as stated in AASHTO LTS-4.
- C. Ice Load: Load of 3 lbf/sq. ft. (143.6 Pa), applied as stated in AASHTO LTS-4.
- D. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.
 - 1. Wind speed for calculating wind load for poles exceeding 50 feet (15 m) in height is 110 mph (177 km/h) from AASHTO LTS-4 for this Project.
 - 2. Wind speed for calculating wind load for poles 50 feet (15 m) or less in height is 110 mph (177 km/h) from AASHTO LTS-4 for this Project.

1.6 SUBMITTALS

- A. Prepare and submit in accordance with Section 01 33 00 – Submittal Procedures.
- B. General:

1. Before releasing any materials, the Contractor shall submit manufacturers' catalog cut sheets, diagrams, and a complete list of all of the equipment and materials which the Contractor intends to install.
 2. The list shall include the brand name, any identifying numbers, relevant technical data, and any other information necessary for the staff responsible for maintenance of the system to procure exact replacements of any and all equipment and material used on the project. All equipment shall be new, first quality and listed by Underwriter's Laboratories, Inc. or other NRTL.
 3. All luminaires of the same type classification shall be provided by the same manufacturer.
 4. Before releasing any non-standard, modification of standard specification product, semi-custom, or custom luminaires, the Contractor shall submit shop drawings which detail methods of assembly and fastening. Shop drawings shall also indicate colors and their locations on each lighting element for review and approval prior to releasing. Contractor shall also supply manufacturer descriptions on luminaires, fabrication performance, and installation.
- C. Luminaire Product Data: For each type of luminaire, arranged in order of luminaire designation. Include data on features, accessories, finishes, and the following:
1. Physical description of luminaire including dimensions.
 2. Driver.
 3. Lamp or Light Source Description including CRI, CCT and initial and L70 lumen output.
 4. SSL Useful Life: IES LM-80 and LM-82 expected useful life at 70% of light output or L70.
 5. LED drivers: Summary of reliability testing performed.
 6. Photometric data, in IES format, based on laboratory tests of each luminaire type, outfitted with light sources, drivers, and accessories identical to those indicated for the luminaire as applied in this Project.
 - a. For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by the manufacturer.
 - b. Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products, including specialty SSL testing.
 - c. For SSL, IES LM-79, LM-80 and LM-82 testing.
 7. Safety certification and file number as required for the luminaire family that must be listed, labeled, or identified per the National Electric Code (NEC). Applicable testing bodies are determined by the U.S. Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratory).

8. Electrical Characteristics: Power Factor (PF), Total Harmonic Distortion (THD), voltage, watts, and SSL repetitive peak current at different dimming ranges.
 9. Dimming: Dimming driver technical information including compatibility with specified control system.
 10. Heat management issues: Insulation Contact (IC) rating if applicable, architectural clearances especially for SSL.
 11. Signed warranty certificates: Required prior to final payment.
- D. Pole Product Data: For each type of pole, arranged in order of pole designation. Include data on features, accessories, finishes, and the following:
- E. Shop Drawings: Show details of nonstandard or custom luminaires. Indicate dimensions, weights, methods of field assembly, light sources, drivers, reflector, refractor, finishes, components, features, and accessories.
1. Wiring Diagrams: Power and control wiring.
- F. Samples for Verification: Submit samples of luminaires if requested. Exterior luminaires designated for sample submission in Exterior Luminaire Schedule. Each sample shall include the following:
- a. For standard catalog types: complete, production line samples, with all installation hardware, proper light source(s) or driver(s), and equipped with a cord and plug (120V).
 - b. Sample of a specially designed or developed luminaire shall be submitted for the purpose of ascertaining its components (hardware, finish, light sources, drivers, reflector, lens, etc), photometric performance, quality of visible parts and details, maintenance features (including re-lamping or light source replacement process), method of installation, safety features, and equipped with a cord and plug (120V).
 - c. Luminaire samples shall be submitted for final review within 30 days after review of shop drawings. If, after a period of 30 days from rejection of samples, the luminaire cannot be made acceptable, then a luminaire (shop drawing and sample) by an alternative manufacturer shall be submitted at no cost to the Owner.
- G. 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 has been included in design.
- H. Product Certificates: The Contractor shall submit all Certificates of Compliance supplied by the manufacturer of the equipment. This equipment shall include, but is not limited to, the following:
1. Luminaires
 2. Light Sources
 3. Drivers
 4. Driver control system compatibility
 5. Luminaire mountings
 6. Photometric data (if requested)

- I. Field quality-control test reports.
 - 1. Grounding
 - 2. Foundation Design
- J. Operation and Maintenance Data: For lighting equipment and luminaires to include in emergency, operation, and maintenance manuals.
- K. Standard Warranties: Provide a written 1 year warranty (5 years for SSL including drivers) on-site replacement material, luminaire, mounting brackets and pole finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products. Finish warranty must include warranty against failure or substantial deterioration such as blistering, cracking, peeling, chalking, or fading. Warranty period must begin on date of possession.
 - 1. For SSL, provide a written 10 year replacement material warranty for defective or non-starting SSL assemblies.
 - 2. For SSL, provide a written 10 year replacement material warranty on all power supply and driver units (PSU).
 - 3. For SSL, provide a written 10 year replacement warranty for luminaires producing inadequately maintained Illuminance levels at end of warranty period, as prorated from levels expected at end of useful life.

1.7 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, with SSL testing (if applicable)
- 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. 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.
- D. Comply with NFPA 70.
- E. Mockups: Provide interior luminaires for room or module mockups, complete with power and control connections.
 - 1. Obtain Architect's approval of luminaires for mockups before starting installations.
 - 2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.

3. Approved luminaires in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- F. Certification: The Contractor shall submit all Certificates of Compliance supplied by the manufacturer of the equipment. This equipment shall include, but is not limited to, the following:
1. Luminaires
 2. Light Sources
 3. Drivers
 4. LED control system compatibility
 5. Luminaire mountings
 6. Poles
 7. Photometric data (if requested)
- G. Operation and Maintenance Data: For lighting equipment and luminaires to include in emergency, operation, and maintenance manuals.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Report all defects and/or conditions that will affect the installation. Contractor shall be held responsible for any existing defects that adversely affect the luminaire or its performance.
- B. All luminaires shall be protected from damage prior to installation.
- C. Upon owner's request, Contractor shall provide one sample of selected luminaires.
- D. Package aluminum poles for shipping according to ASTM B 660.
- E. Store poles on decay-resistant-treated skids at least **12 inches (300 mm)** above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- F. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than **1/4 inch (6 mm)** deep. Do not apply tools to section of pole to be installed below ground line.
- G. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.
- H. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.9 PROJECT CONDITIONS

- A. Weather Restrictions for Installation or Application of the Work is on an as need basis.

- B. Coordinate layout and installation of poles and luminaires with other site and construction conditions.
- C. Notify Architect about field conditions at variance with contract documents before commencing installation. This includes but is not inclusive of changes in site conditions and exterior building conditions and other changes that affect location of equipment.
- D. It is the Contractor's responsibility to coordinate with other trades and with the local utility locator service.

1.10 WARRANTY

- A. Standard Warranties: Provide a written warranty (10 years for SSL including drivers) on-site replacement material, luminaire and pole finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products. Finish warranty must include warranty against failure or substantial deterioration such as blistering, cracking, peeling, chalking, or fading. Warranty period must begin on date of possession.
 - 1. For SSL, provide a written 10 year replacement material warranty for defective or non-starting SSL assemblies.
 - 2. For SSL, provide a written 10 year replacement material warranty on all power supply and driver units (PSU).
 - 3. For SSL, provide a written 10 year replacement warranty for luminaires producing inadequately maintained Illuminance levels at end of warranty period, as prorated from levels expected at end of useful life.
- B. Special Warranty: Provide a written warranty for on-site replacement material, luminaire and pole finish, and workmanship. On-site replacement includes transportation, removal of existing material, and installation of new products. Finish warranty must include warranty against failure or substantial deterioration such as blistering, cracking, peeling, chalking, or fading. Warranty period must begin on date of possession.
- C. 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, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
 - 1. Warranty Period for SSL Luminaires: Ten years from date of Substantial Completion.
 - 2. Special Warranty for SSL Drivers: Manufacturer's standard form in which driver manufacturer agrees to repair or replace drivers that fail in materials or workmanship within specified warranty period.
 - a. Warranty Period for SSL Drivers: Ten years from date of Substantial Completion.

3. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
4. Warranty Period for Color Retention: Five years from date of Substantial Completion.
5. Warranty Period for Light Sources: Replace light sources and fuses that fail within 12 months from date of Substantial Completion; furnish replacement light sources and fuses that fail within the second 12 months from date of Substantial Completion.
6. 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 five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Refer to Exterior Luminaire Schedule for manufacturers and products descriptions.
- B. Basis of Design Products: Drawings and specifications are based on the products listed in the Luminaire Schedule. Products from other manufacturers will be accepted if they meet the requirements of these specifications.
- C. Provide accessories as required for compatibility with installation requirements. Luminaire catalog numbers do not necessarily denote specific mounting accessories for where/how luminaire is to be installed.
- D. All materials used in fabrication and mounting luminaires shall be of a non-corrosive nature.
- E. Luminaires shall be free of light leaks. Luminaires shall be designed to provide adequate ventilation for both light sources and drivers or transformers.
- F. Luminaires shall be designed to hide mounting hardware from view when luminaire is completely installed. Exposed fasteners shall not be acceptable, except as noted on details.
- G. Wiring channels and lamp/light source mountings shall be rigid and accurately manufactured.
- H. In adjustable luminaires, aiming and positive locking devices shall be provided.
- I. All luminaires when installed shall be set true and free of warps, dents, or other irregularities. The finish of exposed parts or trims shall be as specified or as directed by the Architect.
- J. All light source holders shall be of high quality and shall securely hold light sources preventing vibration.

- K. Rivets, springs, and other hardware shall not be visible after installation.
- L. All necessary modifications shall be made to insure compatibility of luminaires with the light sources specified.
- M. All necessary modifications shall be made to insure compatibility of drivers with the light sources and control systems specified.

2.2 MANUFACTURERS

- A. Exterior Luminaire Schedule, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 - 3. Basis-of-Design Product: The design for each luminaire is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.3 MATERIALS

A. LUMINAIRES AND COMPONENTS, GENERAL REQUIREMENTS

- 1. General Requirements
 - a. Luminaires must be the type indicated on Drawings and as specified.
 - b. Luminaires must be of the types and manufacturers described in the Luminaire Schedule, with light source, wattage and voltage as indicated on Drawings. Specific manufacturer and model number references are indicated as a standard of performance and quality. Other manufacturers' models may be supplied provided the product meets or exceeds the specifications per engineer's approval. The alternate luminaires must achieve the similar photometric performance and other quality specifications.
 - c. Luminaire wiring cavity, driver must be field accessible for service or repair needs.
 - d. Luminaire light sources must be field accessible and replaceable for service or repair needs.
 - e. Fully assemble and electrically test luminaires before shipment from factory.
- 2. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
- 3. Comply with IES RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- 4. Comply with IES TM-15 for backlight, uplight and glare (BUG) ratings as indicated in the luminaire schedule.
- 5. Metal Parts: Free of burrs and sharp corners and edges.

6. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.
7. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
8. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping or light source replacement without use of tools. Designed to prevent doors, frames, lenses, diffusers, shielding and other components from falling accidentally during re-lamping or light source replacement and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect driver when door opens.
9. Exposed Hardware Material: Stainless steel.
10. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
11. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
12. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
 - a. White Surfaces: 85 percent.
 - b. Specular Surfaces: 83 percent.
 - c. Diffusing Specular Surfaces: 75 percent.
13. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
14. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
15. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - a. 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."
 - b. 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.
 - 1) Color: As selected from manufacturer's standard catalog of colors.
 - 2) Color: Match Architect's sample of manufacturer's standard color.
 - 3) Color: As selected by Architect from manufacturer's full range.
16. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - a. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

- b. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
 - c. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 - d. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
 - 1) Color: Per manufacturer's standard colors.
17. 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 (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) 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) LED luminaires' photocontrol contact shall be rated with the higher in-rush experienced with LED luminaires.
 - 2) Photocell control shall be UL listed for use with LED luminaires.
 - c. Relay with locking-type receptacle shall comply with NEMA C136.10.
 - d. Adjustable window slide for adjusting on-off set points.
18. DRIVERS FOR SSL (LED AND OLED) LIGHT SOURCES
- a. Efficacy: 85% minimum
 - b. Case Temperature: shall be suitable for operation in the luminaire operating in the ambient temperature, and mounting location constraints.
 - c. Input Voltage: 120 to 277 volts.
 - d. Power supplies can be UL Class I or II output depending on the application.
 - e. Operating frequency must be 50/60Hz.
 - f. Power Factor: Greater than or equal to 0.90.
 - g. Reduction of Hazardous Substances (RoHS) compliant.
 - h. Minimum time between failures (MBTF = total hours of testing / number of failures) shall be greater than 300,000 hours at full load and 25° C ambient, in accordance with MIL-HDBK-217.
 - i. Lifetime: 100,000 hours at full load and 25° C ambient.
 - j. Electromagnetic Interference
 - 1) Shall have a maximum total harmonic distortion (THD) of: ≤ 20% at full input power and across specified voltage range.
 - 2) Shall comply with FCC 47 CFR part 15 non-consumer radio frequency interference/electromagnetic interference standards.
 - k. Dimmable Drivers

- 1) Dimming drivers shall be 0-10V unless specified differently on luminaire schedule.
 - 2) Driver shall be compatible with dimming control equipment.
19. LED LIGHT SOURCES
- a. Coordinate this Article with Drawings. Where color rendition or color uniformity is important and several types of LED light sources are used, provide consistent manufacturer designations or ANSI lamp designations to define requirements.
 - 1) LED Module light source, rated wattage and lumen output as shown in luminaire schedule, CRI 80 (minimum), color temperature 4000 K, and average rated life of 50,000 hours (L70), and suitable for use with dimming drivers, unless otherwise indicated.
 - 2) Power Factor ≥ 0.90 with driver.
 - 3) Total Harmonic Distortion $\leq 20\%$ with driver.
 - 4) No visible flickering when operated with lighting control system.

2.4 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

- A. Poles for this project shall resets only, no new poles required unless contractor damages existing pole during removal, then pole(s) shall be replace with the same specifications as the damaged pole. Pole replacement for contractor damaged poles shall be at no cost to owner.
- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated. Contractor shall provide all adapter plates necessary to install new LED luminaires on the existing poles.
- 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." See plans for exposed foundations.
 1. 2" above exposed above finished grade or as indicated on plans.
 2. 36" exposed above finished grade or as indicated on plans.

2.5 STEEL POLES

- A. Poles for this project shall resets only, no new poles required unless contractor damages existing pole during removal, then pole(s) shall be replace with the same specifications as the damaged pole. Pole replacement for contractor damaged poles shall be at no cost to owner.
 - 1. Shape: Round, tapered steel.
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation.
- B. Steel Mast Arms: Single-arm or double-arm Davit type, continuously welded to pole attachment plate. Material and finish same as pole.
- 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.
- D. Contractor shall repair paint scratches on reset poles with new 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. 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: Color to match existing pole color.

PART 3 - EXECUTION

- A. The installation shall be in accordance with all governing local ordinances and regulations, the Drawings, these special provisions and those sections of the Standard Specifications which apply. All workmanship shall be first class and finished work shall present a neat, uncluttered appearance. The Contractor shall coordinate his work with other construction phases so as to provide a minimum of interference to the combined operations. Contractor shall also coordinate his work with the work on adjacent projects where required.
- B. Completely connect and securely mount all luminaires. Provide all additional supports and hangers as may be necessary to securely fasten and support all luminaires to pole, foundation or structure. All luminaires to be aimed shall be securely locked in place after acceptable aiming.

- C. Clean luminaires and light sources, remove construction dirt, dust, paints, etc, and leave luminaires and light sources in first class condition upon completion of work.
- D. All luminaires and poles shall be plumb and true.
- E. Provide labor and materials for final focusing of all adjustable luminaires under the Lighting Designer's observation. Aim adjustable luminaires in night test of system. Focusing shall take place immediately before Project is turned over to the Owner.
- F. Clean the housing, trim, reflector surfaces, lens of all luminaires after construction is complete, so as to render them free of any material.
- G. Any luminaire damaged during construction shall be replaced without cost to the Owner.
- H. Replace all burned out light sources, or inoperative light sources and/or inoperative drivers and transformers in all luminaires just prior to acceptance of Project by Owner. Verify that all light sources installed are exactly as specified for each luminaire type.
- I. It shall be the Contractor's responsibility to replace and restore all materials in kind, equal to, or exceeding those disturbed by installation. This includes but is not limited to: painting and touch-up and other items as directed by the Architect.
- J. Luminaires: Set level, plumb, and square with buildings, structures and poles.
- K. Install light sources in each luminaire.
- L. 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.

3.2 POLE INSTALLATION

- A. All poles shall be set level and plumb.
- B. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the 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 Storm Drainage Piping: 60 inches (1520 mm).
 - 2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet (3 m).
 - 3. Trees: 15 feet (5 m).
- 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 for light standards 50 foot and shorter.
 - 3. Do not grout the void between pole and foundation on light standards greater than 50 foot or any pole that this action will void the pole manufacturer's warranty.
 - 4. Install base covers, unless otherwise indicated.
 - 5. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- F. Raise and set poles using web fabric slings (not chain or cable).

3.3 BOLLARD LUMINAIRE INSTALLATION

- A. Align units for optimum directional alignment of light distribution as indicated on the plans.
- B. All bollards shall be set level and plumb.
- C. Retain paragraph below if bollards require protection from damage at base due to landscaping maintenance or snow removal operations. Coordinate with Drawings.
- D. Install on concrete base with top 4 inches (100 mm) 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."

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

- A. Install on concrete base with top 4 inches (100 mm) 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."
- B. Install luminaires and aim luminaires per plans.

3.5 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 "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 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, unless otherwise indicated.
 - a. $\frac{3}{4}$ " x 10'-0" copper clad driven or
 - b. Cast in-place 20'-0" of #4 soft drawn bare stranded copper ground wire tie to rebar and coil remainder at the bottom of the foundation.
 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.
 - a. $\frac{3}{4}$ " x 10'-0" copper clad driven or
 - b. Cast in-place 20'-0" of #4 soft drawn bare stranded copper ground wire tie to rebar and coil remainder at the bottom of the foundation.
 2. Install grounding conductor and conductor protector.
 3. Ground metallic components of pole accessories and foundations.

3.7 FIELD QUALITY CONTROL

- A. Prior to final acceptance, the Contractor shall demonstrate by test to the Architect's satisfaction that all the electrical and lighting equipment installations are in proper condition per drawings and specifications. The Contractor shall furnish all equipment and appliances to make the test.
- B. The Architect shall be notified at least two working days prior to energizing the lighting system and the system shall not be put into operation before the Architect is present. All lighting circuits and equipment shall be given an initial operational test, consisting of having the entire system energized for 72 consecutive hours without any failures of any type occurring anywhere in the system. All circuits shall test clear of faults, grounds and open circuits to the satisfaction of the Architect.
- C. After satisfactory completion of all tests, the illumination system shall be placed in operation. Final acceptance will not be made until the system has operated satisfactory for a period of not less than 14 days.

- D. The Contractor shall be fully responsible for the system during this period of operation and he shall make any adjustment or repairs which may be required, and remedy any defects or damages which may occur, at Contractor's expense.
- E. Operation of the system shall not in any way be construed as an acceptance of the system or any part of it or as a waiver of any of the provision of the contract.
- F. The Contractor shall not be required to pay for electrical energy consumed by the system during the period of trial operation.
- G. Inspect each installed luminaire and pole for damage. Replace damaged luminaires, poles and components.
- H. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
 - 1. Verify operation of photoelectric controls.
 - 2. Verify operation of lighting control systems.
- I. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 CLEANING AND PROTECTION

- A. Clean luminaires and light sources, remove construction dirt, dust, paints, etc, and leave luminaires and light sources in first class condition upon completion of work.
- B. Clean the housing, trim, reflector surfaces, lens of all luminaires after construction is complete, so as to render them free of any material.

3.9 SCHEDULE OF PRODUCTS

- A. Refer to Exterior Luminaire Notes on plans.

END OF SECTION 265600