CITY OF THORNTON

SKATE PARK LIGHTING & CONTROLS

Thomas J Slocum (Community) Park

SPECIFICATIONS

100% CONSTRUCTION DOCUMENTS

March 2, 2023

PREPARED BY

ackerman engineering, inc.
3000 Youngfield St, Suite 264
Wheat Ridge, Colorado 802015
Phone 303-278-7297
www.aeiconsulting.com

TABLE OF CONTENTS

END OF TABLE OF CONTENTS

SECTION 03 30 00 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 SUMMARY

A. This Section specifies cast-in place concrete for housekeeping pads and light pole bases, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes.

1.02 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:

1. ACI 301, "Specification for Structural Concrete."
2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

PART 2 - PRODUCTS

2.01 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:

1. Portland Cement: ASTM C 150, Type II.

B. Normal-Weight Aggregates: ASTM C 33, graded, 3/4-inch nominal maximum coarse-aggregate size.

1. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: ASTM C 94/C 94M and potable.

D. Air-Entraining Admixture: ASTM C 260.

E. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

2.02 CURING MATERIALS

A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

B. Water: Potable.

2.03 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork.

2.04 CONCRETE MIXTURES

A. Proportion normal-weight concrete mixture as follows:

1. Minimum Compressive Strength: 3500 psi at 28 days.
2. Maximum Water-Cementitious Materials Ratio: 0.53.
3. Slump Limit: 3-inches to 5-inches, plus or minus 1 inch.
4. Air Content: 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch nominal maximum aggregate size.

PART 3 - EXECUTION

3.01 FINISHING SLABS

A. General: Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture.

1. Apply float finish to surfaces to receive trowel finish.

C. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.

3.02 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.

B. Cure concrete according to ACI 308.1, by one or a combination of the following methods:

1. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

a. After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer unless manufacturer certifies curing compound will not interfere with bonding of floor covering used on Project.

3.03 CONCRETE SURFACE REPAIRS

A. Defective Concrete: Repair and patch defective areas when approved by Engineer. Remove and replace concrete that cannot be repaired and patched to Engineer's approval.

END OF SECTION 03 30 00

Page Intentionally Left Blank

SECTION 26 05 00 COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.01 SCOPE

A. Requirements for the electrical features being furnished and installed under these Specifications shall be in accordance with the requirements of this Section.

B. These Specifications, including the Drawings, outline the general requirements for the electrical design and are based on proposed equipment ratings, locations, and conditions to provide for estimated equipment loads and proposed power and lighting circuit ratings.

C. The CONTRACTOR shall coordinate all electrical installations and designs and shall place the electrical equipment accurately in position; level and plumb, connect, and adjust the electrical equipment; and make the electrical installations ready for service.

D. After the CONTRACTOR has selected the equipment and completed the equipment location, outline and layout drawings, the electrical equipment ratings and power circuits shall be checked, coordinated, and revised as needed.

E. The CONTRACTOR shall furnish and install all materials and equipment and provide all labor required and necessary to complete the work shown on drawings and/or listed below and all other work and miscellaneous items, not specifically mentioned, but inferred for a complete installation, including all accessories and appurtenances required for testing the system. It is the intent of drawings and Specifications that all systems be complete and ready for operation.

F. The CONTRACTOR shall perform electrical systems demolition, cutting and patching for electrical construction, and provide touchup painting.

G. The CONTRACTOR shall contact UNCC 811 two full working days prior to any digging to request utility system locates. Any system, wire, cable, or piping damaged during the construction process shall be repaired or replaced to the Owner’s satisfaction without additional cost to the Owner.

H. The CONTRACTOR shall contact the Owner’s Project Manager to request owner system locates (irrigation systems and/or other buried owner systems). Any system, wire, cable, or piping damaged during the construction process shall be repaired or replaced to the Owner’s satisfaction without additional cost to the Owner.

I. The CONTRACTOR shall notify the Engineer and Owner’s Project Manager a minimum of 48 hours prior to any inspection as well as prior to covering up any work.

1.02 REFERENCES

A. The latest edition of the following standards and codes, standard publications of professional organizations, and the State of Colorado are the minimum requirements for this work.

1. American National Standards Institute (ANSI)
2. American Society for Testing and Materials (ASTM)
3. Association of Edison Illuminating Companies (AEIC)
4. Code of Federal Regulations (CFR)
5. Insulated Cable Engineer's Association (ICEA)
6. Institute of Electrical and Electronic Engineers (IEEE)
7. National Electrical Manufacturer's Association (NEMA)
8. National Fire Protection Association (NFPA)
9. NFPA 70, The National Electrical Code (NEC-latest edition)
10. International Energy Conservation Code (IECC)
11. Underwriters' Laboratories, Inc. (UL)
12. State, City, and Local Authorities

1.03 CONTRACTOR SUBMITTALS

A. General

1. All submittals shall be in accordance with the requirements of this Section and Section 01 33 00 – Submittal Procedures.
2. All drawings and technical data are required to be furnished by the CONTRACTOR shall be written in English, and all units of measurements shall be in the English system. All drawings shall be made expressly for this Contract. Typical drawings are not acceptable. The drawings and data shall be complete and accurate in their content. Originals and all copies shall be legible. Drawings shall be prepared using AutoCAD format and shall be drawn to scale and shall have neat lettering. Freehand sketches will not be accepted.
3. Shop Drawings shall include bills of material, front views, assembly drawings, mounting details, schematic diagrams, elementary diagrams, block diagrams, and wiring diagrams. Shop Drawings shall show overall dimensions and minimum clearances for all electrical equipment. Full-size drawings shall be submitted.
4. The drawings shall be prepared using graphical symbols and device function numbers conforming to the latest applicable standards of ANSI.

B. Approval Shop Drawings and Data

1. The CONTRACTOR shall furnish Shop Drawings, data, and instructions for the equipment for approval by the ENGINEER.
2. Prepare and submit a set of coordination drawings showing major elements, components, and systems of electrical equipment and materials in relationship with other building components. Prepare 11”x17” or 24”x36” drawings to an accurate scale of 1/4"=1'-0" or larger. Indicate the locations of

all equipment and materials, including clearances for servicing and maintaining equipment including (but not necessarily limited to) the following:
   a. Electric equipment room layouts
   b. Mechanical equipment room layouts
3. Prepare coordination drawings for specific equipment installations, including, but not limited to the following:
   a. Generators and automatic transfer switches
   b. Pad mounted and/or dry type transformers
   c. Switchboards and panelboards
   d. Equipment connections
   e. Control panels
   f. Circuit and motor disconnects
   g. Feeder conduits
4. Wiring Diagrams: Provide wiring diagrams indicating field installed electrical power and control wiring and cabling layouts, overcurrent protective devices, equipment, and equipment connections.
5. Material Shop Drawings shall show:
   a. Equipment locations, outlines, and layouts: Approval drawings and information shall show equipment locations with respect to the structure, enclosure construction, conduit entries where applicable, grounding plan showing ground rod locations, dimensions, arrangement of components within the enclosures, and section arrangement.
   b. Bills of material: Bills of material shall give information of each piece of equipment including type, style, manufacturer, and other pertinent information such as scales, trip ratings, settings, and other information, as applicable.
   c. Nameplates: Nameplate lists shall provide information on material, sizes, and engraved lettering.
   d. Schematic Diagrams: Schematic diagram drawings shall show complete functional operation of the equipment including equipment devices and components that are identifiable by reference to the bill of material item.
   e. Wiring diagram: Wiring diagram drawings shall show complete wiring of the equipment devices and components including terminal block numbers and wire (conductor) designations.
   f. Manufacturer's data: Manufacturer's data, such as catalog cut sheets, shall be clearly marked to indicate the item being provided. The data shall provide sufficient comprehensive product information to fully demonstrate that the product meets the requirements of these specifications.

C. Final Drawings

1. The CONTRACTOR shall furnish final drawings for all electrical systems. All final drawings shall show all changes and revision dates made up to the time the drawings are furnished. The drawings shall show "as-built" equipment and installations. All drawings furnished shall apply specifically to the equipment actually furnished. No equipment shall be shipped until the drawings have been updated to show the equipment at the time of shipment.

The final drawings shall include the requirements of 01 33 00 – Submittals. The following final drawings shall be furnished.

a. Outlines and location of equipment relative to the structure.
b. Grounding plan and location of ground rods and grounding connections.
c. Nameplate lists.
d. Panel Directories.
e. Location of conduit hubs, knockouts, openings, and pull boxes.
f. Schematic diagrams.
g. Wiring diagrams.

D. Test Reports

1. The CONTRACTOR shall submit to the ENGINEER certified copies of test reports as required in Section 26 08 00 Testing for Electrical or as required by specific sections of Division 26. Ground resistance or equipment, that does not successfully pass the testing requirements, will be rejected. Equipment tests are defined within Section 26 08 00 Testing for Electrical and the specific equipment requirement Sections elsewhere in these Specifications.

E. Operation and Maintenance Instructions, Descriptive Data, and Bills of Material

1. Each set of material shall be assembled into one binder with a cover and front index sheet.
2. The operation and maintenance instructions shall be descriptive data that apply specifically to the equipment furnished and shall include the features pertaining to operation, maintenance, control, relaying, instrumentation, programming, and other features.
3. Descriptive data and bills of material shall describe the components furnished. These data shall be such that the components can be identified as to manufacturer, type, rating, characteristics, and other identification so that a component to be replaced could be ordered from the description furnished.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to State of Colorado, and marked for intended use.

B. Comply with NFPA 70, the National Electrical Code (latest edition).

C. All equipment and materials will be new and unused and shall conform with the current applicable industry standards. All equipment and materials shall be installed in compliance with manufacturer's recommendations and requirements. Workmanship and neat appearance shall be as important as electrical and mechanical operation. Defective or damaged materials shall be replaced or repaired prior to final acceptance in a manner meeting approval of Architect and/or Engineer and at no additional cost to Owner.

D. The State of Colorado Department of Regulatory Agencies (Electrical Board) is the Authority Having Jurisdiction for this project.

1.05 DEFINITIONS

A. Instructions such as "Provide" shall mean the same as though the words "This Contractor shall" preceded each such instruction. "Provide" shall mean "Furnish and Install." Where the words "Accepted" or "Acceptable" are used, such "Accepted" or "Acceptable" action by the Engineer and/or Architect denotes that the work or equipment item is in conformance with the design concept of the project and, in general, complies with pertinent information given in the Contract Documents.

1.06 SEQUENCING AND COORDINATION

A. The electrical system construction sequence shall follow the general project sequence.

B. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installation.

C. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.

D. Coordinate electrical service components (primary feeder(s), utility company transformer, secondary service entrance feeder, main disconnection means and sequence, metering equipment, grounding, etc.) as well as access and connections to utility company equipment furnished by utility companies.

1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.
2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.

E. No work shall be concealed until after inspection and approval by proper authorities. If work is concealed without inspection and approval, Contractor shall be responsible for all work required to expose and restore the concealed work in addition to all required modifications.

F. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.

G. Where electrical identification markings and devices will be concealed by acoustical ceilings and similar finishes, coordinate installation of these items before ceiling installation.

PART 2 – PRODUCTS

2.01 EQUIPMENT AND MATERIALS

A. Electrical equipment and materials shall be as specified on the drawings and in accordance with standards referenced in Article 1.2.

B. All equipment nameplates shall be in English. All signs and symbols shall be in accordance with ANSI Y32.2.

C. Mounting bolts, nuts, and washers for items of electrical equipment shall be ASTM A276Type 316 stainless steel. Cadmium-plated mounting hardware will not be permitted.

D. Door latching mechanisms on the electrical equipment enclosure shall include combination handle and cylinder-type locks. Handles and locks made of pot metal will not be acceptable. The keys shall be removable in both the locked and unlocked position. Where possible, all locks shall be keyed alike. An identifying serial number shall be stamped on each lock and the associated key. A total of five keys shall be furnished for each differently keyed lock.

E. In addition to the electrical materials specified herein, the CONTRACTOR shall furnish and install shims, grout, expansion anchors, wood blocking, anchor bolts, screws, nuts, washers, and all other hardware and incidentals required to complete the electrical installation.

F. If the CONTRACTOR-furnished electrical equipment and materials are of such size, type, ratings, or other physical properties that changes are required in the approved CONTRACTOR's designs, it shall be the responsibility of the CONTRACTOR to effect all changes necessary as required and approved by the ENGINEER without additional compensation.

G. Nameplates shall be provided in compliance with Section 26 05 53 Identification for Electrical.

2.02 EQUIPMENT FOR UTILITY COMPANY'S ELECTRICITY METERING

A. Current-Transformer Cabinets: Comply with requirements of electrical power utility company.

B. Meter Sockets: Comply with requirements of electrical power utility company.

C. Service Entrance conduit and conductors: Comply with requirements of electrical power utility company.

2.03 TOUCHUP PAINT

A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.

B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

2.04 TOOLS

A. The CONTRACTOR shall furnish all special tools and appliances as required for maintenance and adjustment of electrical equipment. The CONTRACTOR shall furnish all additional tools and equipment as necessary to properly install, adjust, and check the operation of the electrical equipment.

2.05 TEMPORARY FACILITIES:

A. Responsibility for providing electricity for temporary construction facilities and construction equipment, lighting, heating, telecommunications, and other systems shall be as identified in Division 01 and as coordinated between the General Contractor and Division 26 Contractor.

B. If AC power systems or their backup systems serving telecommunications, computer equipment, or their associated HVAC equipment and controls are taken out of service, for any reason, the Contractor shall be responsible for providing temporary systems during the period when the AC power systems or their backup systems are out of service. The Contractor shall be responsible for providing temporary power to all loads being interrupted.

PART 3 - EXECUTION

3.01 ELECTRICAL EQUIPMENT INSTALLATION

A. General

1. Installation of electrical equipment shall be in accordance with the manufacturer's installation instructions. Nuts and bolts used in electrical equipment assembly and installation shall be tightened by the use of torque wrenches to torque values recommended by the equipment manufacturer.
2. The CONTRACTOR shall make all electrical wire, cable, conduit, and grounding connections and furnish all miscellaneous materials that are required for making these connections to the equipment.
3. The CONTRACTOR shall drill all holes and provide all fastenings required for mounting or installing electrical equipment and materials.
4. Any electrical equipment installed on concrete foundations shall be given full and even bearing by being grouted in place. Grouting shall be in accordance with Section 03 30 00 – Concrete
5. Repair of damage to painted and/or galvanized surfaces shall be made in accordance with manufacturer’s recommendations.

6. Repair or replacement of damaged parts shall be in accordance with Article 1.4

B. Equipment Identification

1. The completed electrical installation shall be provided with adequate identification of circuits and equipment to assist personnel during maintenance.
2. Nameplates shall be provided for all panelboards, panels, starters, switches, and push button stations. In addition to the nameplates shown, control devices shall be equipped with standard collar type legend plates, as required.
3. Control devices within enclosures shall be identified with nameplates.
4. Terminal strips shall be identified by imprinted marker strips

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange, and install components and equipment to provide the maximum possible headroom.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Adhere to clearances required by the NEC-latest edition, NFPA 70. Connect for ease of disconnecting, with minimum interference with other installations.

E. Right of Way: Give to raceways and piping systems installed at a required slope.

3.02 UTILITY COMPANY ELECTRICITY-METERING EQUIPMENT

A. Install CT enclosures, meters, service entrance feeders, and other equipment according to the local utility company's written requirements. Coordinate the installation, access to transformers and other utility company equipment with the utility company.

B. Provide grounding, trenching and empty conduits for the primary feeder as required by the local utility company. Install according to the local utility company's written requirements.

3.03 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

B. Coordinate the repair and refinish of disturbed finish materials and other surfaces with the appropriate trade to have areas restored to match adjacent undisturbed surfaces. This contractor is responsible for all costs of repairs required by work performed by this contractor. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.04 FIELD TESTING AND STARTUP

A. After the electrical installations have been completed, the CONTRACTOR shall operationally test the electrical equipment and circuits installed under these specifications, unless specifically indicated otherwise herein, to demonstrate that the requirements of these specifications have been fulfilled.

B. The CONTRACTOR shall have available, at the construction site, drawings that show the electrical installation at the time of the examination, instruction books, equipment tests reports, coordination curves, and data.

C. Immediately prior to the acceptance tests, the CONTRACTOR shall service all electrical equipment in accordance with manufacturer's instructions.

D. While performing the functions of testing and checkout, the CONTRACTOR shall retain full responsibility for the removal and replacement of any wiring connections. The CONTRACTOR shall make wiring changes, setting adjustments, equipment replacements, or other revisions, which are necessary for the proper and adequate functioning of the installation. The CONTRACTOR shall be responsible for and shall replace at the CONTRACTOR’s own expense any wiring, instruments, or equipment which may be damaged in the checkout process.

1. All switches shall be tested for correct operation.
2. All instrumentation systems shall be calibrated and tested for proper operation.
3. The grounding system shall be tested for proper resistance.

3.5 FIELD QUALITY CONTROL

A. Inspect installed components for damage and faulty work, including the following:

1. Raceways
2. Conductors and Cables
3. Supporting Devices for Electrical Components
4. Electrical Identification
5. Concrete Equipment Bases
6. Electrical Demolition
7. Cutting and Patching for Electrical Construction
8. Touchup Painting

3.06 CLEANING AND PROTECTION

A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Final Acceptance.

3.07 WARRANTY

A. The CONTRACTOR shall warranty all electrical workmanship and materials for a minimum of one year or for the warranty period specified in individual sections whichever is greater. The warranty period shall extend from the date of Final Acceptance.

B. In addition to the standard warranties the CONTRACTOR shall attend a warranty walk through meeting to be held at eleven months from the date of Final Acceptance.

END OF SECTION 26 05 00

SECTION 26 05 19 LOW-VOLTAGE POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SCOPE

A. This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600V and less.

1.02 REFERENCES

A. The latest edition of the following standards and codes are the minimum requirements for this work.

1. Insulated Cable Engineer's Association (ICEA)
2. InterNational Electrical Testing Association (NETA ATS)
3. National Electrical Contractors Association (NECA)
4. National Electrical Manufacturer's Association (NEMA)
5. National Fire Protection Association (NFPA)
6. NFPA 70, The National Electrical Code (NEC-latest edition)
7. Underwriters' Laboratories, Inc. (UL)

1.03 SUBMITTALS

A. The CONTRACTOR shall submit manufacturers' catalog data for the wire and cables in accordance with the requirements of this Section, Section 26 05 00 – Common Work Results for Electrical, and Section 01 33 00 –Submittal Procedures.

1.04 QUALITY ASSURANCE

A. Listing and Labeling: Provide wires and cables specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 MATERIALS

A. The insulated conductors furnished shall be of the proper voltage rating, type, and size for the application, and shall have been manufactured within twenty four (24) months prior to receipt of the notice to proceed under this contract. All conductors shall be stranded copper unless specifically stated otherwise. All conductors shall

be suitable for installation in a vertical position. All conductors shall have an AWG or kcmil designation.

B. 600-Volt, Single Conductor for General Use Other Than Direct Burial: The insulated conductors shall conform to the requirements of NEC-latest edition, shall bear the UL label, shall be suitable for general use other than direct burial, and shall be NEC-latest edition type THW, THWN/THHN or XHHW.

C. Polyethylene warning tape: Polyethylene warning tape for installation above buried power feeders shall be 6 inches wide, yellow in color, with CAUTION printed continuously the full length of the tape.

D. Multiconductor Power and Control Cable: Multiconductor cables shall be provided as noted on the Drawings. The multiconductor cables shall be as follows:

1. 600 volts insulated.
2. Multiconductor type suitable for installation in trays and conduits.
3. Individual conductors shall be insulated with NEC-latest edition type THHN insulation and color-coded.
4. Polyester tape, or equivalent, over the conductor group.
5. Shielded with 100 percent aluminum foil taper and with minimum No. 18 AWG tinned and copper drain wire.
6. An overall covering (jacket) of thermoplastic or neoprene.
    a. Cable with No. 14 AWG individual conductors:
        (1) 3/C and smaller - 45 mils thick.
        (2) 4/C to 12/C - 60 mils thick.
        (3) Over 12/C - 80 mils thick.

E. Instrumentation Cable: The instrumentation cable shall be suitable for all uses and shall be as follows:

1. Twisted pair, individually shielded, having varying lengths of lay to minimize crosstalk.
2. UL listed and labeled, Type TC.
3. Voltage: 300V.
4. Conductors tinned copper, stranded, and No. 18 AWG minimum.
5. Pair Shield: Aluminum coated Mylar with tinned copper drain wire, No. 18 AWG minimum.
6. Jacket: Plenum Rated.
7. Conductor Identification: ICEA S-61-402, black and white in pairs. White conductor printed numerically for group identification.

F. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Wires and Cables:
    a. Southwire Company.
    b. The Okonite Company

c. USA Wire & Cable, Inc.

2. Connectors for Wires and Cables:
   a. AMP Incorporated.
   b. General Signal; O-Z/Gedney Unit.
   c. 3M Company; Electrical Products Division.

2.02 WIRES AND CABLES 600-VOLT NOMINAL OR LESS

A. UL-listed building wires and cables with appropriate ratings for installed application.

B. Rubber Insulation Material: Comply with NEMA WC 3.

C. Thermoplastic Insulation Material: Comply with NEMA WC 5.

D. Cross-Linked Polyethylene Insulation Material: Comply with NEMA WC 7.

E. Ethylene Propylene Rubber Insulation Material: Comply with NEMA WC 8.

F. Factory applied color coded insulation the entire length of conductors for all wire.

G. Conductor Material: Copper.

H. Stranding: Solid conductor for No. 10 AWG and smaller (except for Engine/Generator Control Wiring); stranded conductor for larger than No. 10 AWG.

I. Insulation Color: All insulated conductors (service entrance, feeder, and branch circuit) shall have full colored insulation, colors as specified in Section 26 05 53 Identification For Electrical Systems, for the entire length of the conductor. Neutral conductors installed, in compliance with the NEC-latest edition for each single pole breaker, shall have a tracer stripe to match the phase conductor color. (Contact Omnicable.com / 303-574-9444 or equivalent for striped conductors).

J. Use of MC cable is prohibited except for luminaire connection whips (from homerun j-box to luminaire).

K. Use of AC, NM, ENT, or other manufactured pre-wired systems cable is prohibited.

2.03 CONNECTORS AND SPLICES 600-VOLT NOMINAL OR LESS

A. UL-listed, factory-fabricated wiring connectors of size, ampacity rating, material, type, and class for application and service indicated. Comply with Project's installation requirements and as specified in Part 3 “Wire and Insulation Applications" Article.

B. Electrical Tape:

1. Plastic tape, 8.5 mils maximum thickness, 1,000,000 megohms minimum insulation resistance, oil-resistant vinyl backing, oil-resistant acrylic adhesive, incapable of supporting combustion per ASTM D-568 Test Method B.
2. 3M +33 Type.

C. Cable Lubricants:

1. Wire pulling lubricants shall be specifically recommended by the cable manufacturer for assisting in pulling jacketed cables. Cable lubricants shall be soapstone, graphite, or talc for rubber or plastic-insulated cables. Lubricants shall be rated for use in low temperatures (-20º F). Lubricant shall not be deleterious to the cable sheath, jacket, or outer coverings.
2. Ideal Yellow #77, Aqua Blue, Poly Water, Dyna Blue or equivalent.

2.04 MISCELLANEOUS WIRING MATERIAL

A. Miscellaneous Connecting and Splicing Devices: Miscellaneous products, such as heat shrink tubing, electrical insulation, plug caps, splices and kits, tapes, terminal blocks, and terminations, shall be approved for the specific application.

B. Joint compounds shall be approved for the specific type of metal joint to be prepared.

C. Cable ties, clamps, and identification shall be nylon, self-locking.

D. Fire-seal fittings, certified by UL, for installation where sleeves penetrate fire-rated walls, floors, etc., as required by NEC-latest edition Article 300-21. Size fire seals for the application.

PART 3 - EXECUTION

3.01 GENERAL

A. All wiring shall be in compliance with the NEC-latest edition: All single phase branch circuits originating at single pole or multi-pole breakers (120V single phase circuits, or 277V single phase circuits) shall be installed with a dedicated neutral conductor for each phase conductor. The neutral conductor shall have a tracer stripe (the stripe color shall match the color of the phase conductor).

B. All wiring shall be routed through an UL-listed raceway regardless of voltage application, unless specified otherwise on the drawings or under other sections of these Specifications.

C. Derate conductor ampacities based on the NEC-latest edition when more than three current carrying conductors are installed in one raceway.

D. No conductors or cable shall be pulled into any portion of conduit system until all construction work, which might damage the wire, has been completed and

raceways have been swabbed. In no case shall wire be left exposed where students and staff may have access.

E. Lubricate cables to facilitate pulling. Lubrication material shall be inert to cable and raceways and rated for -20°F for pulling #4AWG and larger wires.

F. Install compression connectors with hydraulic die, embossing die code into connector. Connect to bus with Belleville type washers for positive pressure over complete contact area. Insulate with heat shrink tubing.

G. Sizes of conduits, unless specifically shown otherwise, shall be determined from Chapter 9 of the latest National Electrical Code based on THW wire in electric metallic tubing.

3.02 INSTALLATION 600 VOLTS, NOMINAL OR LESS GENERAL

A. Unless otherwise indicated, all wiring for branch circuits shall be #12 AWG protected by 20-ampere circuit breakers. Wire size shall be increased to account for voltage drop for all 120-volt circuits over 75 feet, and all 277-volt circuits over 150 feet to the first outlet. Wire size shall be uniform for the entire length of the circuit unless noted otherwise. Homeruns which indicate upgrading circuit conductors for voltage drop, e.g., #10AWG wire on 20-ampere circuit, shall have the conductor size indicated carried throughout the circuit to the last device or fixture.

B. Do not splice feeders or dedicated branch circuits unless otherwise indicated. Install all wire continuous from outlet to outlet or terminal to terminal. Splices in cables when required shall be made in handholes, pull boxes or junction boxes and shall be in strict accordance with cable manufacturer's recommendations utilizing solderless connectors UL approved for the use (splices for pole mounted luminaires shall be made in the curved carlon box installed in the pole base unless the pole base is flush with grade in which case splices shall be made in the pole handhole). Make up splices in outlet boxes with 8 inches of correctly color-coded tails left in box. Splices in wires size #10AWG and smaller shall be made with insulated spring type wire connectors, "Scotchlok." Use U.L. listed compression connectors (Ilsco Clear Tap or Burndy Hi Press), for wire splices and taps, #8AWG and larger. All insulating tape used on circuits of 600 volts and less shall be 3-M +33. Tape or heat shrink uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of the conductor. Terminate spare conductors with electrical tape.

C. Make connections, splices, taps and joints with solderless devices, mechanically and electrically secure.

D. Provide a separate neutral for dimmer branch circuits, ground fault interrupter branch circuits, lighting branch circuits serving electronic ballasts.

E. All phase, neutral, and ground conductors shall be tagged with corresponding circuit numbers at panelboard as well as at all junction and outlet boxes.

F. Make all ground, neutral, and line connections to receptacle and wiring device terminals by means of the side terminal screw connections. Branch conductors shall not be connected to the device with backside “push-in” connectors. Provide ground jumper from outlet box to ground terminal of receptacle.

3.03 STORAGE AND HANDLING

A. Store wiring materials in a protected environment not subject to physical damage or the effects of sunlight or inclement weather.

3.04 FIELD QUALITY CONTROL

A. Wire and Cable Tests (600 Volts): Measure the insulating resistance of service entrance conductors, feeder circuit conductors, and service ground. Measurements shall be taken between conductors and between conductors and ground. Resistance shall be 1,000,000 ohms or more when tested at 500 volts by megger without branch circuit loads. Tests and procedures shall meet the approval of the ENGINEER and shall be in accordance with the applicable ICEA standards for the wires and cables to be installed. Furnish all instruments, equipment, and personnel required for testing, and conduct tests in the presence of the ENGINEER Submit written reports of the tests and results to the ENGINEER.

B. Testing: On installation of wires and cables and before electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.

C. Correct malfunctioning conductors and cables at Project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

END OF SECTION 26 05 19

SECTION 26 05 26 GROUNDING AND BONDING FOR ELECTRICAL

PART 1 - GENERAL

1.01 SCOPE

A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.02 REFERENCES

A. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
ANSI/ASTM B3 Soft or Annealed Copper Wire
ANSI/ASTM B8 Concentric-Lay –Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ANSI/UL 467 Grounding and Bonding Equipment

B. NFPA70 – NATIONAL ELECTRICAL CODE (NEC-latest edition)

1.03 DEFINITIONS

A. Bonding and Grounding for Telecommunications / Data Communications Systems:
Telecommunications Main Grounding Busbar (TMGB)
Telecommunications Grounding Busbar (TGB)
Telecommunications Bonding Backbone (TBB) conductor.

1.04 SUBMITTALS

A. Product Data: For the following:

1. Ground rods
2. Ground bars
3. Ground enhancement material

B. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

C. Field Test Reports: Submit written test reports to include the following:

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.

D. The CONTRACTOR shall submit manufacturers catalog data for the grounding materials, grounding drawing, and test reports in accordance with the requirements of this Section, Section 26 05 00 – Common Work Results for Electrical, and Section 01 33 00 –Submittal Procedures.

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the State of Colorado and marked for intended use.

1. Comply with UL 467.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Grounding Conductors, Cables, Connectors, and Rods:
   a. ILSCO.
   b. Kearney/Cooper Power Systems.
   c. Lyncole XIT Grounding.
   d. O-Z/Gedney Co.; a business of the EGS Electrical Group.
   e. Raco, Inc.; Division of Hubbell.
   f. Thomas & Betts, Electrical.

2. Grounding Bus Bars for power and telecommunications systems:
   a. Chatsworth (CPI)
   b. Cooper B-Line
   c. Erico (nVent)
   d. Harger
   e. Hubbell
   f. ILSCO.
   g. Legrand (Ortronics)
   h. Panduit
   i. Thomas & Betts, Electrical.

2.02 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 26 Section "Low-Voltage Power Conductors and Cables."

B. Material: Copper.

C. Equipment Grounding Conductors: Insulated with green-colored insulation.

D. Grounding Electrode Conductors: Stranded cable.

E. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.

F. Bare Copper Conductors: Comply with the following:

1. Solid Conductors: ASTM B 3.
2. Assembly of Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.

G. Copper Bonding Conductors: As follows:

1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inch (6.4 mm) in diameter.
2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches (42 mm) wide and 1/16 inch (1.5 mm) thick.
4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches (42 mm) wide and 1/16 inch (1.5 mm) thick.

H. Grounding Bus Bar: Bare, annealed copper bars of rectangular cross section, mounted to wall with insulators. Bus bar dimensions shall be 1/4-by-4-by-20-inch minimum (6.35-by-100-by-500-mm), copper or copper alloys having a minimum of 95% conductivity.

2.03 CONNECTOR PRODUCTS

A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Bolted Connectors: Bolted-pressure-type connectors, or compression type. Burndy Hi-Press series lugs, ILSCO Clear Taps may be used for wire sizes #8 through 500kcmil.

C. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

2.04 GROUNDING ELECTRODES

A. Ground Rods: Sectional type; copper-clad steel.

1. Size: 3/4 in diameter by 120 inches.

B. Concrete Encased Ground Electrode: The concrete encased ground electrode shall consist of a minimum of 20 feet of bare #4 copper conductor or larger installed as a single run, or #5 rebar or larger installed as a single run, or multiple column (2 or more) grid with equal size cross members 18 inches on center welded (or

double-tied) together, installed within the foundation or footer and encased with a minimum of two inches of concrete cover in all directions.

PART 3 - EXECUTION

3.01 APPLICATION

A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. In raceways, use insulated equipment grounding conductors.

C. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.

D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

E. Ground Rod Clamps at Test Wells: Use bolted pressure clamps with at least two bolts.

3.02 EQUIPMENT GROUNDING CONDUCTORS

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment grounding conductors in all feeders and branch circuits. This grounding conductor shall be in addition to the ground path provided by the continuously grounded metallic raceway system that encloses the phase and neutral conductors . Where there are parallel feeders installed in more than one raceway, each raceway shall have a green insulated equipment ground conductor. Provide ground bushings bonded to grounding conductor at both ends of all feeder conduits.

C. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.

D. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 volts and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.

E. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and antifrost heating cable. Bond conductor to heater units, piping, connected equipment, and components.

F. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide insulated grounding conductor in raceway

from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location in compliance with TIA-607-D.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a telecommunications grounding bus bar.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

G. Metal Poles Supporting Outdoor Lighting Fixtures: Provide a grounding electrode in addition to installing a separate equipment grounding conductor with supply branch-circuit conductors.

3.03 INSTALLATION

A. Ground Rods: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.

1. Drive ground rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
2. Interconnect ground rods with grounding electrode conductors. Use exothermic weld connections without exposing steel or damaging copper coating.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

C. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

D. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

E. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.

F. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Where metallic piping and duct systems are rendered metallically non-continuous by non-conductive couplings, provide bonding jumpers to restore grounding continuity. Use braided-type bonding straps.

G. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.

H. Bonding and Grounding for Telecommunications / Data Communications Systems: For telephone, alarm, voice, data, and other communication systems, provide TMGB in the MDF, and a TGB in each IDF. TMGB is interconnected to each TGB by a TBB conductor.

1. Service and Central Equipment Locations such as the MDF or other communications entrance facility: Provide a TMGB bonded to facility Electrical Service Grounding Busbar.

3.04 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

B. All connections to ground buses shall be by mechanical means.

C. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

D. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors. Use Burndy QGFL 34 B1 type connectors for attachment to building steel

E. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate both ends of conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

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

G. Compression-Type Connections (#8 and Larger): Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

H. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.05 FIELD QUALITY CONTROL

A. Tests: Perform the following field quality-control testing:

1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
2. Test completed grounding system at each at service disconnect enclosure grounding terminal, the maximum ground-resistance shall not exceed 5 ohms. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.
3. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

B. Final testing and reporting shall be performed by the independent testing firm.

END OF SECTION 26 05 26

Page Intentionally Left Blank

SECTION 26 05 29 HANGERS AND SUPPORTS FOR ELECTRICAL

PART 1 - GENERAL

1.01 SCOPE

A. The CONTRACTOR shall furnish and install supports, fasteners, and anchors for all electrical conduits; boxes, switchboards, panelboards, transformers, and accessories required for a complete and secure electrical system. The term "conduit" shall be considered synonymous with the term "raceway" as defined in Article 100 of the NEC-latest edition.

1.02 REFERENCES

A. The latest edition of the following standards and codes are the minimum requirements for this work.

NFPA No. 70 National Electrical Code (NEC-latest edition)

1.03 SUBMITTALS

A. The CONTRACTOR shall submit product data, drawings, and descriptive information in accordance with the requirements of this Section, Section 26 05 00 – Common Work Results for Electrical, and Section 01 33 00 –Submittal Procedures.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. For structures assigned to Seismic Design Category B, C, D, E or F, where the requirements of Section 13.2.1 of ASCE 7 for nonstructural components, supports or attachments are met by seismic qualification as specified in Item 2 therein, components shall meet the seismic qualification by analysis, testing or experience data. Certificates of compliance for the seismic qualification shall be submitted to the Building Official/Authority Having Jurisdiction.

2.02 SUPPORTING DEVICES FOR ELECTRICAL COMPONENTS

A. Provide hangers and supports to support raceways, fixtures, cabinets, boxes, etc. as manufactured by B-Line, Caddy, Unistrut, or Kindorf.

B. Material: Cold-formed steel, with corrosion-resistant coating.

C. Metal Items for Use Outdoors or in Damp Locations: Steel, hot-dip galvanized after fabrication.

D. Slotted-Steel Channel Supports: Flange edges turned toward web, and 9/16-inch-(14-mm-) diameter slotted holes at a maximum of 2 inches (50 mm) o.c., in webs.

1. Channel Thickness: Selected to suit structural loading.
2. Fittings and Accessories: Products of the same manufacturer as channel supports.

E. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, trapeze hangers, wall brackets, roof supports, and spring-steel clamps or click-type hangers.

1. Trapeze hangers shall be an assembly consisting of parallel vertical threaded rods suspended from structure, using support devices and methods listed herein, connected at the lower ends by a horizontal slotted steel channel member. All components shall be engineered and manufactured specifically for use and assembly as supports/hangers.

F. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.

G. Fabricated supports, use structural steel or steel channel, rigidly welded, or bolted to present a neat appearance.

H. Expansion Anchors: Carbon-steel wedge or sleeve type. Anchors shall be removable type.

I. Toggle Bolts: All-steel springhead type.

J. Mounting bolts, nuts, and washers for items of electrical equipment shall be ASTM A276Type 316 stainless steel. Cadmium-plated mounting hardware will not be permitted.

K. Perforated pipe strap and wire supports are prohibited.

L. Powder-actuated anchors are prohibited without specific written permission.

M. Concrete housekeeping pads for transformers and free standing floor mounted switchgear enclosures and cabinets shall be in compliance with Division 3 Concrete. Housekeeping pads shall be a minimum of four inches high and extend 3 inches beyond the footprint of the supported equipment.

N. Door latching mechanisms on the electrical equipment enclosure shall include combination handle and cylinder-type locks. Handles and locks made of pot metal will not be acceptable. The keys shall be removable in both the locked and unlocked position. Where possible, all locks shall be keyed alike. An identifying serial number shall be stamped on each lock and the associated key.

PART 3 – EXECUTION

3.01 GENERAL

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC-latest edition requirements.

1. Fasten supports directly to structure. Do not fasten supports to piping, ductwork, mechanical equipment, conduit, or ceiling system suspension wires or wire of any type.
2. Drilling or other modification of structural steel members is prohibited without specific written permission from the structural engineer.

B. Coordinate with the building structural system and with other electrical installation.

C. Electrical system layouts indicated on drawings are generally diagrammatic but shall be followed as closely as actual construction and work of other trades will permit. Govern exact routing of raceways and locations of outlets by structure and equipment served. Take all dimensions from architectural drawings.

D. Consult all other drawings. Verify all scales and report any dimensional discrepancies or other conflicts to Architect before submitting bid.

E. Avoid cutting and boring holes through structure or structural members wherever possible. Obtain prior approval of Architect and conform to all structural requirements when cutting or boring structure is necessary and permitted.

F. Raceway Supports: Comply with the NEC-latest edition and the following requirements:

1. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits. Provide a minimum of 20% space available for future raceways for all multiple raceway supports.
2. Support parallel runs of horizontal raceways together on trapeze-type hangers.
3. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings. For hanger rods with spring steel fasteners, use 1/4-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
4. Space supports for raceways in accordance with NEC-latest edition, but in no case shall support spacing exceed 8-feet between supports or 2-feet from any box or conduit body.
5. Support raceway within 1 foot of box and access fittings.

6. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway connections.
7. Wire will not be allowed for conduit support.

G. Panelboards: Comply with the NEC-latest edition and the following requirements:

1. Install surface-mounted cabinets and panelboards with minimum of four anchors.
2. Bridge between studs above and below recess mounted cabinets and panelboards with channels to support cabinets in stud walls.
3. Align tops of all adjacent cabinets.

H. Transformers and Freestanding Switchgear Enclosures: Concrete housekeeping pads shall be provided for all transformers and free standing floor mounted switchgear enclosures. Secure transformers and free standing switchgear to concrete housekeeping pads with a minimum of four anchors per section.

1. Transformers smaller than 15 kVA may be wall-mounted. Transformers 15 kVA and larger shall be floor-mounted unless otherwise shown on the drawings. Provide Korfund elasti-rib vibration isolations pads along with rubber washers for all mounting bolts. Where wall-mounted, provide factory mounting brackets.

I. Fasten hanger rods, conduit clamps, and outlet and junction boxes to building structure using expansion anchors or preset inserts.

J. Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls.

K. Use expansion anchors or preset inserts in solid masonry walls

L. Use self-drilling anchors or expansion anchor on concrete surfaces

M. Use sheet metal screws in sheet metal studs.

N. Use hexagon head bolts with spring lock washers under all nuts.

O. Sleeves: Install in concrete slabs and walls for raceways and cable installations. All penetrations through walls and floors shall be sealed. For non-rated walls and floors apply additional materials used in penetrated wall construction (grout, gyp-board and tape, etc.) or non-rated gap sealant.

For sleeves through fire rated-wall or floor construction, apply UL- listed fire-stopping sealant in gaps between sleeves and enclosed conduits and cables in accordance with sealant manufacturer’s requirements.

END OF SECTION 26 05 29

SECTION 26 05 33 RACEWAYS AND BOXES FOR ELECTRICAL

PART 1 - GENERAL

1.01 SCOPE

A. The CONTRACTOR shall furnish and install all electrical conduits; boxes, and accessories required for the installation of conductors for the power, control, and instrumentation services. The term "conduit" shall be considered synonymous with the term "raceway" as defined in Article 100 of the NEC-latest edition.

1.02 REFERENCES

A. The latest edition of the following standards and codes are the minimum requirements for this work.

ANSI C80.1	Rigid Steel Conduit, Zinc-coated
ANSI C80.6	Intermediate Metal Conduit, Zinc-coated
ANSI C80.3	Electrical Metallic Tubing, Zinc-coated
NEMA FB 1	Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies
NEMA RN 1	Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC2	Rigid Nonmetallic Conduit (Schedule 40 and Schedule 80)
NEMA TC 3	PVC Fittings for Use with Rigid PVC Conduit and Tubing
NFPA No. 70	National Electrical Code (NEC-latest edition)
UL-651	Standard for Safety Schedule 40 and 80 PVC Conduit

B. Sizes of conduits, unless specifically shown otherwise, shall be determined from Tables in Chapter 9 of latest National Electrical Code (latest edition).

1.03 SUBMITTALS

A. The CONTRACTOR shall submit drawings, data, and descriptive information in accordance with the requirements of this Section, Section 26 05 00 – Common Work Results for Electrical, and Section 01 33 00 –Submittal Procedures.

PART 2 - PRODUCTS

2.01 RACEWAYS AND FITTINGS

A. Metallic Conduit Systems:

1. Electrical Metallic Conduit (EMT). EMT shall be zinc-coated steel, galvanized on the outside and coated on the inside with a hard smooth lacquer finish. EMT fittings shall be steel set-screw type with insulated throats.

2. Flexible Metal Conduit (FMC): FMC shall be single strip, continuous, flexible interlocked double-wrapped steel, zinc-coated inside and out forming smooth internal wiring channel with steel compression fittings.
3. Intermediate Metal Conduit (IMC): IMC shall be hot-dipped galvanized with a zinc-coating. Fittings shall be steel threaded type.
4. Liquidtight Flexible Steel Conduit (LFSC): FLSC shall be zinc-coated steel the same as FMC except with sunlight-resistant and mineral-oil-resistant plastic jacket. Fittings shall be cast malleable iron or steel body and gland nut, cadmium-plated with one-piece brass grounding bushings threaded to interior of conduit. Provide spiral molded vinyl sealing ring between gland nut and bushing and nylon insulated throat.
5. Rigid Steel Conduit (RSC): RSC shall be heavy wall, hot dipped galvanized steel inside and out with threaded ends. RSC fittings shall be steel, threaded type. Plastic-coated Rigid Steel Conduit shall be rigid galvanized steel conduit having a 0.030"(.762 mm) minimum thick factory-bonded PVC jacket, using pre-jacketed couplings as manufactured by Pittsburgh Robroy, Plastic Applicator, Occidental or approved equal.

B. Nonmetallic Conduit Systems:

1. Rigid Nonmetallic Conduit (RNC): RNC shall be polyvinyl chloride (PVC) Schedule 40 or 80 suitable for 90°C. Provide solvent cemented type fittings matched to conduit type and material**.**
2. Liquidtight Flexible Nonmetallic Conduit (LFNC): LFNC shall comply with UL3.

C. Metal Wireways: Wireways shall be hinged cover or screw cover complete with all necessary manufactured fittings which shall be of one manufacturer. Wireway shall be G.E. Type HS or ITE KEL Duct or acceptable equal.

1. Material: Sheet metal sized and shaped as indicated.
2. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system. Provide wire retainers at not greater than 12 inches (300 mm) on center.
3. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.
4. Wireway Covers: Hinged type
5. Exterior, wet, or damp locations shall be NEMA 250 Type 3R
6. Finish: Manufacturer's standard enamel finish

D. Bushings: For steel conduit larger than 1/2-inch size, provide insulated type bushings, designed to prevent abrasion of wires without impairing the continuity of the conduit grounding system. Grounding bushings shall be locking type and shall be provided with a feed-through compression lug for securing the ground cables. Unions shall be electro-galvanized ferrous alloy type Appleton UNF or UNY, Crouse-Hinds UNF or UNY, or equal.

Grounding bushings shall be steel type and installed at both ends of the conduit on all feeders, as well as all transformer, motor, motor controller, kitchen, and TVSS equipment branch circuits.

E. Sealing Fittings: Provide threaded, zinc or cadmium coated, cast or malleable iron type for steel conduits. Fittings used to prevent passage of water vapor shall be of the continuous drain type.

F. Provide minimum ¾" conduit for all circuit homeruns from the source panel to the first device

G. Flexible Metallic and Flexible Non-Metallic conduit installations shall be limited to 6ft in length.

H. Use of MC cable is prohibited except for luminaire connection whips (luminaire connection whips from a homerun j-box to each individual luminaire, luminaire to luminaire is not allowed. Maximum of 6 feet length for connecting luminaires in accessible ceilings to the local junction box. Maximum of 3 feet length for connecting luminaires in non-accessible ceilings to the local junction box.).

I. Use of AC, NM, ENT, or other manufactured pre-wired systems cable is prohibited.

2.02 SURFACE METAL RACEWAYS

A. Surface metal raceway components, fittings, and accessories shall be of one manufacturer, designed and listed for use together as surface metal raceway.

1. Sheet metal channel with fitted cover.
2. Couplings, elbows, and connectors shall be designed for use with the raceway system.
3. Boxes and extension rings shall be designed for use with the raceway systems. (extension rings are not allowed on new construction, one extension ring is allowed on existing recessed boxes where conductor length will still comply with the latest NEC requirements)
4. Use flat head screws to fasten channel to surfaces.
   a. Option: Use suitable clips and straps
5. Use insulating bushings and inserts at connections to outlets and corner fittings.
6. Maintain grounding continuity between raceway components.

B. Acceptable Manufacturers:

1. Carlton, Hubbell, IsoDuct, Panduit, Square D, Walker, Wiremold, or equivalent.

2.3 OUTLET, JUNCTION AND PULL BOXES

A. Acceptable Manufacturers:

1. Boxes and Cabinets; Bell, Bowers, Raco, Steel City, Appleton, Carlton, Lew Electric, National Electric Products, or equivalent.
2. Floor boxes; Walker, Hubbell, Raceway Components Inc., Bowers, Rotco Inc., Steel City, Appleton, Lew Electric, or equivalent.

B. Outlet, Junction and Pull Boxes:

1. Cast Type Boxes: Cast type boxes shall be ferrous alloy and have gasketed cast covers and inside threaded hubs with adapters as necessary. Cast-metal boxes shall comply with NEMA 3R. Covers shall be cast metal weatherproof while in-use type.
2. Galvanized Pressed Steel Type Boxes: Boxes shall be pressed steel, galvanized or cadmium-plated (4-inch x 2 1/8" deep minimum square for all wall locations, 4 11/16-inch x 2 1/8" deep minimum square for all above ceiling locations), with galvanized cover or extension ring as required (extension rings are not allowed on new construction, one extension ring is allowed on existing recessed boxes where conductor length will still comply with the latest NEC requirements). Knockout type shall be used with knockouts removed only where necessary to accommodate the conduit entering. Boxes shall comply with NEMA OS 1. Provide a grounding terminal in each box containing a green equipment ground conductor, or serving motors, lighting fixtures, or receptacles. Grounding terminal shall be green-colored washer-in-head machine screw or grounding bushing.
3. Field gang type boxes are prohibited in all applications and extension boxes are prohibited on new construction.
4. Floor Boxes and Fittings:
   a. General: Provide surface floor boxes and fittings of the types, ratings, and configurations as shown on the Drawings.
5. Cover and Device Plates: Provide device plates for each switch, receptacle, signal and telephone outlet, and special purpose outlet. Do not use sectional gang plates. Provide multi-gang outlet plates for multi-gang boxes. Provide high impact thermoplastic or nylon for devices in finished areas, and galvanized steel on surface-mounted devices in unfinished areas, unless otherwise selected by Architect. Surface outlet coverplates shall have beveled edges. Color of thermoplastic device plates shall be the same as the device or as selected by Architect.
6. Cut-in/after-set boxes are not allowed.

C. Metal Pull boxes: Pullboxes shall be screw cover complete with all necessary manufactured fittings which shall be of one manufacturer.

1. Material: Sheet metal sized and shaped as indicated.
2. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.
3. Exterior, wet, or damp locations shall be NEMA 250 Type 3R
4. Finish: Manufacturer's standard enamel finish

D. Flush with grade enclosures and pull boxes shall be QUAZITE® as manufactured by Strongwell or approved equal. The pull/splice box shall be constructed of

polymer concrete consisting of sand and aggregate bound together with a polymer resin. Internal reinforcement may be provided by means of steel, fiberglass, or a combination of the two. Boxes and covers shall be concrete gray and sustain a minimum vertical test load of 22,568# over a 10" square. Boxes shall be stackable for extra depth.

PART 3 - EXECUTION

3.01 GENERAL

A. Electrical system layouts indicated on drawings are generally diagrammatic but shall be followed as closely as actual construction and work of other trades will permit. Govern exact routing of raceways and locations of outlets by structure and equipment served. Take all dimensions from architectural drawings.

B. Consult all other drawings. Verify all scales and report any dimensional discrepancies or other conflicts to Architect before submitting bid.

C. All home runs to panelboards are intended to be started from outlet nearest panel and continuing in general direction of that panel. Continue such circuits to panel as though routes were completely indicated. Terminate homeruns of signal, alarm, and communications systems in a similar manner.

D. Avoid cutting and boring holes through structure or structural members wherever possible. Obtain prior approval of Architect and conform to all structural requirements when cutting or boring structure is necessary and permitted.

E. Furnish and install all necessary hardware, hangers, blocking, brackets, bracing, runners, etc. required for equipment specified under this section.

F. Raceways shall be installed and complete prior to pulling any wire into raceway.

3.02 RACEWAYS - GENERAL

A. Protect all non-PVC coated metallic raceway in earth or fill from corrosion with two coats of corrosion resistant paint or tape wrap.

B. Elbows for conduit installed below grade or floor slabs and vertical conduit risers to above grade or floor slabs shall be rigid steel conduit with factory PVC coating or two coats of corrosion resistant paint or tape wrap.

C. Tie embedded raceways securely in place prior to concrete placement. Raceways installed below floor slabs shall extend a minimum of 4 inches (100 mm) above the finished slab or housekeeping pad to the first connector. Install capped bushings on conduit stub ups.

D. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb. (90-kg) tensile strength. Leave

at least 12 inches (300 mm) of slack at each end of the pull wire. Tag both ends noting destination.

E. Use temporary raceway caps to prevent foreign matter from entering conduits.

F. Make all bends using an approved bending tool. Make conduit bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated. Cut all conduits square and ream all cuts to remove burrs. Exercise all necessary precautions during the construction period to prevent entry or accumulation of moisture, dust, concrete, and all foreign matter into the raceway system. The contractor shall pull a mandrel through each raceway to ensure the raceway interior is clean and dry prior to pulling conductors or cable.

G. Make bends in exposed parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for exposed parallel raceways.

H. Connect motors and equipment subject to vibration, noise transmission, or movement with a maximum of 72 inch (183 cm) liquid tight flexible conduit. Install separate ground conductor across flexible connections.

I. Above grade - defined as areas above finished grade for a building exterior and above top surface of any slabs (or other concrete work on grade) for a building interior. Installation of and materials for above-grade raceways shall conform with the following:

1. Install conduit concealed within finished walls, ceilings, and floors except at surface cabinets, for motor and equipment connections, and in building service equipment rooms unless otherwise indicated. Surface metal raceways shall be used where raceways are specified or allowed to be installed exposed in finished areas.
2. Route all conduit/raceways, exposed and concealed, parallel or perpendicular to building lines with right angle turns and symmetrical bends.
3. Paint all surface conduit, installed in finished areas, to match the adjacent surfaces on which it is mounted.
4. Install raceways a minimum of 6 inches (150 mm) away from parallel runs of flues and steam pipes or other heated lines. Locate horizontal raceway runs above water and steam piping.
5. Install raceways a minimum of 6 inches below the roof deck.
6. Provide for waterproofing of all raceways, outlets, fittings, etc. which penetrate exterior walls or the roof to preserve the weatherproof integrity of the building. Provide pockets for waterflashing and counterflashing or pitch pockets for waterproofing of all raceways, outlets, fittings, etc. which penetrate roof. Wherever conduits penetrate concrete walls to outdoors, the Contractor shall provide a watertight seal as manufactured by O.Z. Gedney Company, Type CSMC; Thunderline Corporation, Link Seal, or equal.

7. Raceways between cabinets, fittings or boxes shall not exceed 200 feet (60 m) for straight runs or 100 feet (30 m) for runs with the maximum number of bends.
8. Provide one empty 3/4-inch (20 mm) conduit for each set of three spare circuit breakers or spaces in flush-mounted panelboards into the overhead accessible ceiling space.
9. Raceways Above Suspended Ceilings:
    a. Raceways shall not be supported from ceiling support wires. Provide independent support of raceways.
    b. Install conduit 1 foot (300 mm) minimum above top of ceiling.
10. Rigid metallic steel conduit shall be installed in the following above-grade areas:
    a. Where exposed/surface mounted, exterior locations, and where subject to damage. Rigid steel conduit shall extend to a minimum of 8-feet above finished floor/grade.
    b. Where specifically required by the National Electrical Code.
11. Electrical Metallic Tubing (EMT): Shall be installed in:
    a. Concealed locations in furred or masonry walls or ceilings.
    b. Embedded in poured insulating fills.
    c. Exposed areas at least 4 feet (2.5 m) above floor.
12. Liquid tight flexible metal conduit shall be provided in sufficient lengths for makeup of motors, transformers, or equipment, and/or raceway connections where isolation of sound and vibration transmission is required. Liquid-tight flexible metal conduit shall contain a separate equipment grounding conductor, sized per NEC-latest edition requirements.
13. Flexible metallic and non-metallic conduit shall not exceed 6 feet (1.8 m) in length. Flexible 3/8-inch fixture whip connections to recessed lighting fixtures shall not exceed 6 feet (1.8 m) in length.
14. Surface raceways, where indicated on drawings, shall be metal and of a size approved for number and size of wires to be installed and shall be installed in a neat, workmanlike manner, with runs parallel or perpendicular to walls and partitions. Raceways, elbows, fittings, outlets and devices shall be of same manufacturer, and designed for use together.
15. Conduit Supports and Fasteners:
    a. Supports: Provide supports for horizontal steel conduits and EMT not more 2 feet from boxes and conduit bodies, and not more than 8 feet (2.5 m) apart with one support near each elbow or bend, including runs above suspended ceilings.
    b. Individual: Install spring steel fasteners with hanger rods on conduits 1-1/2 inch (40 mm) or smaller. Install individual pipe hangers for conduits larger than 1-1/2 inch (40 mm).
    c. Trapezes: Install multiple (trapeze) pipe hangers where two or more horizontal conduits run parallel and at the same elevation. Secure each conduit to the horizontal hanger member by a U-bolt, one-hole strap or other specially designed and approved fastener. Install 3/16-inch (5 mm) diameter or larger steel rods for trapezes, spring steel fasteners, clips and clamps. Wire or perforated strapping shall not be used for the support of any conduit.

d. Roof Top Conduit Support: Fasten pipe to stands specifically manufactured for support of pipes installed on roofs. Stands shall support pipe a minimum of 6 inches above the roof and be resistant to damage from environmental conditions and other causes such as birds. Stands shall be Caddy Pyramid 50 series or equivalent. Support stands requiring fastening through the roof membrane are prohibited.
e. Fastening: Fasten pipe straps and hanger rods to concrete by means of inserts or expansion bolts, to brickwork by means of expansion bolts, and to hollow masonry by means of toggle bolts. Wooden plugs and shields shall not be used. Power-driven fasteners may be used to attach pipe straps and hanger rods to concrete where approved by Architect. Install raceway on steel construction with approved clamps which do not depend on friction or set-screw pressure alone.

16. Fittings: Use approved type couplings and connectors in all conduit runs, and make all joints tight. Provide insulated bushings or rain-tight connections with insulated throats for all terminations in pipe sizes 1-1/4" (32 mm) and larger. Provide waterproof fittings for all runs in wet locations, such as exposed to weather, buried in slabs, etc. Provide raceway expansion joints, in compliance with NEC-latest edition and approved by the State, with necessary bonding conductor at building expansion joints, between structures and where required to compensate for raceway or building thermal expansion and contraction.

J. Below Grade: Defined as area below finished grade for a building exterior and below bottom floor slab for a building interior. Installation of and materials for below-grade raceways shall conform with the following:

1. Elbows for conduit installed below grade or floor slabs and vertical conduit risers to above grade or floor slabs shall be rigid steel conduit with factory PVC coating or two coats of corrosion resistant paint or tape wrap.
2. Below-grade raceways shall turn up and extend 48 inches minimum above floor or equipment foundation.
3. Install conduits below slab-on-grade concrete 12 inch minimum below bottom of concrete slab unless shown otherwise on the drawings.
4. Install exterior underground conduits 30 inch minimum below finished grade unless shown otherwise on the drawings.
5. Non-encased Raceways: Unless specifically noted on drawings for concrete encasement, provide either of the following raceway systems for installation below slabs on grade or in earth or gravel.
   a. Rigid, heavy-wall, Schedule 40 or 80, polyvinyl chloride PVC plastic conduit, suitable for direct burial. All offsets and 90-degree ells shall be rigid plastic-coated conduit. Provide continuous ground wire for all non-metallic conduits.
   b. Rigid steel conduit that is not completely encased in concrete but is in contact with ground or on a vapor barrier shall be wrapped with Scotchrap 51 half-lapped or shall have an additional outside factory coating of polyvinyl chloride with a minimum coat thickness of 30 mils (0.762 mm). Other PVC or Phenolic-resin-epoxy coating material, which is equally flexible and chemically resistant, may be used

providing approval by the Engineer is obtained prior to installation. Provide pre-jacketed couplings to provide a substantially watertight jacketing system.

c. All underground conduits and ducts 2 inches (50 mm) and larger shall be proven clear by pulling through a ball mandrel (diameter approximately 85% of conduit inside diameter) followed by close fitting wire brush and wad of felt or similar material. Clear raceway of all obstructions and dirt prior to pulling in wires or cables. Clean empty raceways similarly. Clear or replace any raceway which rejects ball mandrel.

d. Provide seal-off fittings where conduits enter or leave hazardous wiring area or areas of widely different temperature and/or humidity.

6. Non-Metallic Raceway Installations:

a. Joints shall be made using the material recommended by the raceway manufacturer. Components shall be cleaned prior to assembly.

b. Raceway cutoffs shall be square and shall not deform conduit. Ream rough surfaces.

c. Provide male box adapters to terminate raceways.

d. Where separable terminations are required, provide PVC threaded adapters with locknuts or bushings. Provide "O" rings for watertight installations.

e. Bends shall be made by methods that do not deform or damage the conduit.

f. Provide expansion fittings where required in compliance with NEC-latest edition and approved by the State.

g. Raceway supports shall be installed to allow the non-metallic conduit to slide through the supports.

h. Non-metallic raceway is not permitted within the building.

3.03 OUTLET, JUNCTION AND PULL BOXES

A. Provide galvanized or zinc-coated, pressed steel outlet boxes for all locations except where otherwise indicated or where cast metal boxes are required by the NEC-latest edition. Provide plaster or tile rings for all flush outlets installed where wood, drywall, tile, plaster, etc. types of finishes are applied. All outlets for exterior application shall be cast, weatherproof type, with gasket and cast coverplate. Tile boxes of extra depth may be used for interior, dry applications where masonry block or brick walls constitute the finished wall surface. In any event, provide outlet boxes of proper type and design for the particular fixture or device to be installed. Structural conditions and obstructions or other equipment items shall govern exact location of outlets and equipment. When necessary, relocate outlets so that when fixtures or equipment are installed, they will be symmetrically located according to room layout and will not interfere with other work or equipment. Verify final location of all outlets, panels, equipment, etc. with Architect and/or Engineer.

B. Equip light fixture outlet boxes with 3/8-inch (10 mm) no-bolt fixture studs. Provide a minimum 4-inch (100 mm) octagon box. Where fixtures are mounted on or in an accessible type ceiling, provide a junction box and extend flexible conduit to each fixture. Outlet boxes in finished ceilings or walls shall be fitted with appropriate

covers, set to come flush with the finished surface. Where more than one switch or device is located at one point, use gang boxes and covers unless otherwise indicated. Sectional switch boxes or utility boxes will not be permitted. Provide tile box or a 4-inch (100 mm) square box with tile ring in masonry walls which will not be plastered or furred, or where "drywall" type materials are applied.

C. Except as otherwise noted, locate outlet boxes as follows: Dimensions given are from finished floor to center line of outlets. Adjust heights of outlets in masonry walls to correspond with consistent brick or block course. Outlets in block walls shall be installed in core of block.

1.	Wall switch outlets	44 inches (112 cm)
2.	Convenience outlets, long axis vertical-ground pole up or horizontal-ground pole on left side	18 inches (46 cm)

D. Junction and Pull Boxes: Use outlet boxes as junction boxes wherever possible. Larger junction and pull boxes over 12 inches (300 mm) in any dimension shall be fabricated from sheet steel, sized according to NEC-latest edition, and have screw-on covers. All junction boxes shall be accessible.

E. Surface-mounted device boxes mounted below 8 feet shall be Metal Surface Raceway boxes or (Bell) cast-type boxes with threaded knock-outs (without knock-outs other than as required by conduit entering/leaving).

F. Flush with Grade Pull Boxes: Provide junction/pull boxes wherever underground conduit runs exceed 500 feet or where required to comply with the maximum number/radius of bends per the NEC. Junction/Pull boxes shall be sized according to NEC-latest edition and have lockable screw-on covers. All junction boxes shall be accessible.

END OF SECTION 26 05 33

SECTION 26 05 53 IDENTIFICATION FOR ELECTRICAL

PART 1 - GENERAL

1.01 SCOPE

A. This Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and the State of Colorado.

1.02 REFERENCES

A. NFPA 70 National Electrical Code (NEC-latest edition)

B. NESC National Electrical Safety Code

1.03 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. All submittals shall be in accordance with the requirements of this Section, Section 26 05 00-Common Work Results for Electrical, and Section 01 33 00 – Submittal Procedures.

1.04 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

C. Comply with ANSI A13.1 and NFPA 70 for color-coding.

PART 2 - PRODUCTS

2.01 RACEWAY AND CABLE LABELS

A. Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Pretensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the line it identifies and arranged to stay in place by pretensioned gripping action when placed in position.

C. Aluminum, Wraparound Marker Bands: Bands cut from 0.014-inch- (0.4-mm-) thick aluminum sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.

D. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

E. Tape Labels: Embossed adhesive tape, with 3/16 inch white characters.

F. "Kroy" Labels: Kroy tape with 3/8 inch minimum characters.

2.02 NAMEPLATES AND SIGNS

A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

B. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16-inch (1.6 mm) thick for signs up to 20 square inches (129 square cm) and 1/8-inch (3.2 mm) thick for larger sizes.

1. Punched or drilled for mechanical fasteners.

C. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

2.03 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.

B. Paint: Formulated for the type of surface and intended use.

1. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.
2. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

C. Polyethylene warning tape: Polyethylene warning tape for installation above buried power feeders shall be 6 inches wide, yellow in color, with CAUTION printed continuously the full length of the tape.

PART 3 - EXECUTION

3.01 INSTALLATION

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

B. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.

C. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations. Use consistent designations throughout Project.

1. White characters on black background for "Normal",
2. White characters on red background for "Emergency" and fire alarm devices
3. White characters on green background for "Ground".

D. Install painted identification according to manufacturer's written instructions and as follows:

1. Clean surfaces of dust, loose material, and oily films before painting.
2. Prime surfaces using type of primer specified for surface.
3. Apply one intermediate and one finish coat of enamel.

E. Color Banding Raceways and Exposed Cables: Band exposed and accessible raceways of the systems listed below:

1. Apply the following colors to the systems listed below:
   a. Fire Alarm System: Red
   b. Emergency Power System: Red

F. Device Coverplates: Use preprinted label for identification of circuits at all individual wall switches and receptacles, control device stations. Locate label on the front side of the coverplate as well as identify circuits with permanent ink on the backside of the coverplate.

G. Wire Identification: Provide wire markers on each conductor in panelboard gutters, pull boxes, outlet and junction boxes, and at load connection. Identify with branch circuit or feeder number as indicated on equipment manufacturer’s shop drawings for control wiring.

H. Junction Box and Pull Box Identification: Use indelible black marker to inscribe circuit or bus, switch numbers and source panel on the outside of each junction and pullbox cover.

I. Panel Directories: Provide TYPED, UPDATED Panel Directories for all Distribution Feeder and Branch Circuit Panels modified by this project.

J. Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches (400 mm) overall, use a single line marker. Install line marker for underground wiring, both direct-buried cables and cables in raceway.

K. Secondary Service, Feeder, and Branch-Circuit Conductors: Factory Color-coded insulation throughout the entire length of the conductor

1. Color-code 208/120-volt system as follows:
   a. Phase A: Black
   b. Phase B: Red
   c. Phase C: Blue
   d. Neutral: White with a phase colored stripe
   e. Ground: Green

2. Color-code 480/277-volt system as follows:
   a. Phase A: Brown
   b. Phase B: Orange
   c. Phase C: Yellow
   d. Neutral: Gray with a phase colored stripe
   e. Ground: Green

3. 0-10V Lighting and System Control wire installed with power conductors:
   a. Purple and Pink

4. Lighting Controls:
   a. Yellow

5. Factory applied colored insulation the entire length of all conductors.

L. Equipment Identification Labels for Equipment Above Ceilings: Engraved plastic laminate. Fastened to ceiling grid or access door below each electrical device or electrical unit of equipment installed above the ceiling.

M. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. Apply labels for each unit of the following categories of equipment using mechanical fasteners:

1. Distribution and control equipment
   a. Identify equipment as well as loads served
   b. 1/4 inch lettering for equipment designation
   c. 1/8 inch lettering to identify voltage rating, fault current rating
   d. 1/8 inch lettering to identify fuse rating/type for all fused disconnects
   e. 1/8 inch lettering to identify feeder conduit & wire size information
   f. 1/8 inch lettering to identify feeder source

2. Individual Circuit Breakers and Switches in Panelboards and Switchboards:
   a. 1/8 inch lettering to identify circuit and load served, including location.
   b. 1/8 inch lettering to identify feeder conduit & wire size information

3. Panelboards, Switchboards, electrical cabinets, and enclosures:
   a. 1/4 inch lettering for equipment designation
   b. 1/8 inch lettering to identify voltage rating, fault current rating
   c. 1/8 inch lettering to identify feeder conduit & wire size information

d. 1/8 inch lettering to identify feeder source

4. Individual Control Equipment (timeclocks, lighting control cabinets and contactors):
   a. 1/8 inch lettering to identify circuit and load served, including location.
   b. 1/8 inch lettering to identify voltage rating, fault current rating
   c. 1/8 inch lettering to identify feeder conduit & wire size information
   d. 1/8 inch lettering to identify feeder source

5. Individual Circuit Breakers, Enclosed Disconnect Switches, and Motor Starters:
   a. 1/8 inch lettering to identify load served.
   b. 1/8 inch lettering to identify voltage rating, fault current rating
   c. 1/8 inch lettering to identify feeder conduit & wire size information
   d. 1/8 inch lettering to identify feeder source

6. Transformers:
   a. 1/4 inch lettering to identify equipment designation.
   b. 1/8 inch lettering to identify primary and secondary voltages, primary source, and secondary load and location.
   c. 1/8 inch lettering to identify load served
   d. 1/8 inch lettering to identify feeder conduit & wire size information
   e. 1/8 inch lettering to identify feeder source

7. Main Grounds:
   a. 1/4 inch lettering "Do Not Disconnect".
   b. Label “Grounding Electrode Conductor” and “Main bonding Jumper” with engraved tags, 1/4 inch lettering.

8. Devices Above Ceilings:
   a. 1/4 inch lettering to identify equipment designation.
   b. Mechanically fastened to ceiling below device.

9. Tele-Data:
   a. Identify telephone / data raceways with the label ”TELE-DATA” on pull and junction boxes and conduit at the termination points, 1/4 inch lettering.
   b. Identify Telephone Termination Backboard with the label “TELEPHONE”.

N. Equipment Warning Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. Apply labels for each unit of the following categories of equipment using mechanical fasteners:

1. Clearance requirements for all Panelboards, Switchboards, Electrical Cabinets, and Transformers (clearance shall be stated as 36 Inch minimum for equipment rated equal to or less than 150 volts to ground, and 42 inches minimum for equipment rated more that 150 volts to ground):
   a. 1/2 inch lettering stating the following:

CAUTION:
DO NOT STORE EQUIPMENT AND/OR
MATERIALS IN FRONT OF THIS ELECTRICAL
EQUIPMENT

MAINTAIN MINIMUM ___ INCHES OF CLEAR
AREA IN COMPLIANCE WITH THE
NATIONAL ELECTRICAL CODE

O. Equipment Warning Labels: Arc-Flash Hazard Warning. Electrical equipment, such as switchboards, switchgear, panelboards, industrial control panels, meter socket enclosures, and motor control centers, shall be field or factory marked to warn qualified persons of potential electric arc flash hazards. The marking shall meet the requirements below and shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

1. The marking shall adequately warn of the hazard using effective words, colors, or symbols in compliance with the NFPA 70E, 130.5(C) Equipment Labeling. Equipment labeling for the arc flash hazard shall have one or more of the following: (a.) Available incident energy at corresponding working distance; (b.) Minimum arc rating of clothing; (c.) Required level of PPE; (d.) Highest Hazard Risk Category for the equipment; Nominal system voltage; and Arc flash boundary.

2. The label shall be permanently affixed to the equipment or wiring method and shall not be handwritten.

3. The label shall be of sufficient durability to withstand the environment involved.

END OF SECTION 26 05 53

SECTION 26 08 00 TESTING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SCOPE

A. The drawings and general provisions of the contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.

1.02 TEST REPORT SUBMITTALS

A. Provide a single submittal with examples of test reports for each system to be tested to the Owner/Architect/Engineer prior to testing in accordance with Division 1.

B. Submit results of testing (1 hard copy and 1 electronic (PDF) copy) for each system to the Owner/Architect/Engineer when complete in accordance with Division 1.

1.03 SCOPE/DIVISION OF RESPONSIBILITY

A. EC shall mean the Contractor, ITF shall mean an Independent Testing Firm.

B. The Contractor shall perform routine insulation resistance, continuity, and rotation tests for all distribution and utilization equipment prior to any acceptance testing.

C. The Contractor shall test all lighting, devices, utilization equipment, services, and all circuits for proper operating conditions prior to acceptance testing.

D. The Contractor shall perform visual and mechanical inspections, verifying that the equipment nameplate information meets the intent of the drawings and specifications.

E. The Testing Firm shall be responsible for obtaining/coordinating all final settings and adjustments on protective devices and tap changes with the Engineer, prior to final inspection.

F. The Testing Firm shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections.

G. It is the purpose of these tests to assure that all tested electrical equipment is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications and manufacturer's requirements.

H. The tests and inspections shall determine suitability for energization. Equipment shall not be energized until accepted by the testing firm.

I. An itemized description of equipment to be inspected and tested by the Testing Firm is as follows:

1.	Distribution panelboards	EC or ITF
2.	Transformers	EC or ITF
3.	Cables and Wiring	EC or ITF
4.	Grounding System	ITF only
5.	Ground Fault Systems	ITF only
6.	Circuit Breakers	EC or ITF
7.	Protective Relays	EC or ITF
8.	Electrical Wiring Devices	EC or ITF

J. The Contractor shall supply a suitable and stable source of power to each test site. The testing firm shall specify the specific power requirements.

K. The Contractor shall notify the testing firm when equipment becomes available for acceptance testing. Work shall be coordinated to expedite project scheduling.

L. The Contractor shall supply a complete set of electrical plans, specifications, and any pertinent change orders to the testing firm prior to commencement of testing.

M. The Testing Firm shall notify the Contractor of any system, material, or workmanship which is found defective.

N. The Testing Firm shall maintain a written record of all tests, and upon completion of the project shall assemble and certify a final test report to Architect/Engineer/Owner.

1.04 SAFETY AND PRECAUTIONS

A. Safety practices shall include, but are not limited to, the following requirements:

1. Occupational Safety and Health Act
2. Accident Prevention Manual for Industrial Operations, National Safety Council
3. Applicable state and local safety operating procedures
4. Owner's safety practices
5. National Fire Protection Association - NFPA 70E
6. American National Standards for Personnel Protection

B. All tests shall be performed with apparatus de-energized (Thermographic Survey shall be performed under load). Exceptions must be thoroughly reviewed to identify safety hazards and devise adequate safeguards.

C. The testing firm shall coordinate with the Contractor's safety representative on the project to supervise the testing operations with respect to safety.

1.05 QUALIFICATIONS OF TESTING FIRM

A. The testing firm shall be a corporately and financially independent testing organization which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems evaluated by the testing firm.

B. The testing firm shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.

C. The testing firm shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or be a Full Member company of the InterNational Electrical Testing Association.

D. The lead, on-site, technical person shall be currently certified by the InterNational Electrical Testing Association (NETA) or National Institute for Certification in Engineering Technologies (NICET) in electrical power distribution system testing or equal.

E. The testing firm shall utilize engineers and technicians who are regularly employed by the firm for testing and engineering services. All studies, tests, and reports shall be sealed by a registered electrical professional engineer with a current stamp in the state that this project is located.

F. The testing firm shall develop and provide a detailed “Testing Submittal” for review and approval by the engineer two weeks before any testing is required to be performed. The submittal shall include a complete resume and statement of qualifications from the testing firm detailing the following:

1. Company History
2. Equipment Calibration Program
3. List of Equipment to be Tested
4. Specific Test Procedures to be utilized on this project, along with the applicable test values to determine pass or fail.
5. Sample test forms that are applicable to this project.
6. NETA Certificate

G. The terms used here within, such as test agency, test contractor, testing laboratory, or contractor test company, shall be construed to mean the testing firm.

H. Test Equipment Suitability: Comply with NETA ATS, Section 5.2.

I. Test Equipment Calibration: Comply with NETA ATS, Section 5.3.

1.06 APPLICABLE CODES, STANDARDS, AND REFERENCES

A. All inspections and tests shall be in accordance with the following codes and standards except as provided otherwise herein:

1. National Electrical Manufacturer's Association - NEMA
2. American Society for Testing and Materials - ASTM
3. Institute of Electrical and Electronic Engineers - IEEE
4. InterNational Electrical Testing Association - NETA Acceptance Testing Specifications - ATS-1999
5. American National Standards Institute - ANSI C2: National Electrical Safety Code
6. Codes and ordinances of the State, County, and City

7. Insulated Cable Engineers Association - ICEA
8. Association of Edison Illuminating Companies - AEIC
9. Occupational Safety and Health Administration - OSHA
10. National Fire Protection Association - NFPA
    a. ANSI/NFPA 70: National Electrical Code
    b. ANSI/NFPA 70B: Electrical Equipment Maintenance
    c. NFPA 70E: Electrical Safety Requirements for Employee Workplaces
    d. ANSI/NFPA 780: Lightning Protection Code
    e. ANSI/NFPA 101: Life Safety Code

B. All inspections and tests shall utilize the following references:

1. Project design specifications
2. Project design drawings
3. Short-circuit and coordination study as stated in Paragraph 1.04-D, 2.02, 2.03, 2.04 and 2.05.
4. Manufacturer's instruction manuals applicable to each particular apparatus
5. Project list of equipment to be inspected and tested as stated in Paragraph 1.04.

PART 2 – PRODUCTS

2.01 EQUIPMENT ARC FLASH/SHORT CIRCUIT EVALUATION STUDY

A. An equipment evaluation study shall be performed to determine the adequacy of circuit breakers, controllers, surge arresters, busways, switches, and fuses by tabulating and comparing the short-circuit ratings of these devices with the available fault currents. Any problem areas or inadequacies in the equipment shall be promptly brought to the Owner/Engineer's attention.

B. An equipment evaluation study shall be performed to determine the arc flash hazards of the electrical distribution system and proper Personal Protective Equipment (PPE) requirements for personnel working on the equipment. Provide appropriate Arc Flash Energy / PPE Labeling for all equipment.

2.02 PROTECTIVE DEVICE COORDINATION STUDY

A. A protective device coordination study shall be performed to check the selections of low-voltage breaker trip characteristics and settings in relation to upstream and downstream circuit breaker characteristics and settings. If possible, this study shall be performed on Captor, Version 4.5.

B. The coordination study shall include all voltage classes of equipment from the switchboards down to and including each motor control center and/or panelboard. The phase and ground overcurrent protection shall be included, as well as settings for all other adjustable protective devices.

C. The selection of settings for the protective devices shall be provided separately in a tabulated form listing circuit identification, IEEE device number, current transformer

ratios, manufacturer, type, range of adjustment, and recommended settings. A tabulation of the recommended power fuse selection shall be provided for all fuses in the system. Discrepancies, problem areas, or inadequacies shall be promptly brought to the Owner/Engineer's attention.

2.03 STUDY REPORT

A. The results of the power system study shall be summarized in a final report. Three bound copies of the final report shall be submitted to the Owner/Architect/Engineer.

B. The report shall include the following sections:

1. Description, purpose, basis, written scope, and a single-line diagram of the portion of the power system which is included within the scope of study.
2. Tabulations of circuit breaker, fuse, and other equipment ratings versus calculated short-circuit duties, and commentary regarding same.
3. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.
4. Fault current tabulations including a definition of terms and a guide for interpretation.
5. Tabulation of appropriate tap settings for relay seal-in units.

PART 3 - EXECUTION

3.01 SWITCHGEAR, SWITCHBOARDS, AND PANELBOARDS

A. Visual and Mechanical Inspection:

1. Inspect for physical damage.
2. Verify proper installation. This includes alignment, anchorage, clearances, grounding, bending radius of cables, wiring aesthetics, etc.
3. Inspect for proper identification, nameplate ratings, sizes of protective devices, switches, and busses, and adherence to one-line diagrams.
4. Check tightness of accessible bolted bus joints, cable connections, and anchor bolts.
5. Physically test all electrical or mechanical interlocks to assure proper function.
6. Inspect for proper operation of space heaters and thermostat settings (if applicable)
7. Clean interior and insulator surfaces.
8. Exercise all active components and verify proper barrier and shutter installation and operation.
9. Verify proper neutral and ground connections.
10. Implement settings of overcurrent protective devices per the coordination study.

B. Electrical Tests:

1. Perform insulation –resistance tests on each bus section, phase-to-phase and phase-to-ground for one minute in accordance with NETA Table 10.1 of ATS 1999 Edition.
2. Perform overpotential tests on each MV bus section phase-to-ground, for one minute in accordance with NETA Table 10.2 of ATS 1999 Edition.
3. Perform control wiring performance test and insulation resistance tests on control wiring.
4. Perform phasing check to insure proper bus phasing from each source.
5. Perform thermographic survey on equipment.

C. Test Values:

1. Bolt-torque levels shall be in accordance with values specified by manufacturer or NETA Table 10.12 of ATS 1999.
2. Insulation-resistance test shall be performed in accordance with manufacturer's recommendations. Overpotential tests should not proceed until insulation-resistance levels are raised above minimum values.

3.02 TRANSFORMERS - DRY-TYPE

A. Visual and Mechanical Inspection:

1. Verify installation with manufacturer's requirements.
2. Compare equipment nameplate with single-line diagram, specification, and report discrepancies.
3. Inspect for physical damage, cracked insulators, tightness of connections, defective wiring, and general mechanical and electrical conditions.
4. Check tightness of accessible bolted electrical joints in accordance with manufacturer's recommendations.
5. Verify proper core grounding and equipment grounding.
6. Verify proper clearance between transformer dead-front and termination lugs.

B. Electrical Tests:

1. Perform insulation-resistance tests, winding-to-winding and windings-to-ground, in accordance with NETA Table 10.5 of ATS 1999.
2. Perform dielectric absorption tests, winding-to-winding and windings-to-ground for ten minutes. Compute the polarization index.
3. Perform turns-ratio tests between windings for all tap positions.
4. Perform Doble power factor tests on all high- and low-voltage windings-to-ground.
5. Verify that the tap-changer is set at specified ratio.
6. Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading. Record the following no-load voltages:

Primary	VAB	VAG
	VBC	VBG
	VCA	VCG

Secondary	VAB	VAN	VNG
	VBC	VBN	
	VCA	VCN	

7. Perform phase rotation tests. Verify proper color coding of primary and secondary conductors.

C. Test Values:

1. Insulation-resistance test values at one minute should not be less than the values calculated in accordance with the formula in NETA Table 10.5 of ATS 1999. Winding-resistance test values should compare within one percent (1%) of adjacent windings.
2. The acceptable polarization index shall be in range from not less than 1.25 to greater than 2.0.
3. Turns ratio test results shall not deviate more than one-half percent from either the adjacent coils or the calculated ratio.
4. Power factor values shall be in accordance with limits established by Doble and the transformer manufacturer.

3.03 CABLES - LOW-VOLTAGE - 600V MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect cables for physical damage and proper connection in accordance with single-line diagram.
2. Test cable mechanical connections to manufacturer's recommended values using a calibrated torque wrench.
3. Check cable color coding with applicable Engineer's specifications and National Electrical Code standards.

B. Electrical Tests:

1. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts dc for 1 minute.
2. Perform continuity test to insure proper cable connection.
3. Perform phase rotation tests. Color code conductors.

C. Test Values:

1. Bolt torque values should be in accordance with NETA Table 10.12 of ATS 1999 unless otherwise specified by the manufacturer.
2. Evaluate insulation-resistance results by comparison with cables of same length and type. Investigate any values less than 100 megohms.

3.04 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Inspect ground system for compliance with codes, drawings and specifications.

B. Electrical Tests:

1. Perform fall-of-potential test or alternative in accordance with IEEE 81 on the main grounding electrode and the perimeter ground.
2. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.
3. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

C. Test Values:

1. The maximum ground-resistance shall not exceed 5 ohms. If resistance to ground exceeds specified values, notify Owner/Architect/Engineer promptly and include recommendations to reduce ground resistance.

3.05 GROUND FAULT SYSTEMS

A. Visual and Mechanical Inspection:

1. Inspect for physical damage.
2. Inspect neutral main bonding connection to assure:
   Proper size
   Zero sequence system is grounded upstream of sensor.
   Ground strap systems are grounded through sensing device.
   Ground connection is made ahead of neutral disconnect link.
3. Verify ground electrode conductor(s) for proper size and connection.
4. Check proper operation of a Ground Fault panel (if present).
5. Verify pickup and time delay settings with Engineer.

B. Electrical Tests:

1. Measure system neutral insulation resistance.
2. Measure pickup current by primary injection at sensor.
3. Measure time delay at two (2) points above pickup current level by injecting current into the sensor. Total trip time will be electrically monitored.
4. Test system operation at fifty-five percent (55%) rated voltage for systems with external control power.
5. Test zone interlock systems by simultaneous sensor current injection and monitoring zone blocking function.

C. Test Values:

1. System neutral-to-ground insulation resistance shall be a minimum on one megohm.
2. Relay timing shall be in accordance with manufacturer's specifications.

3.06 LOW VOLTAGE CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:

1. Inspect for physical damage.
2. Mechanical operational test will be made in accordance with manufacturer's instructions.
3. Check tightness of all hardware connections.
4. Check cell fit and element alignment (if applicable).

B. Electrical Tests:

1. Perform a contact resistance test.
2. Perform an insulation resistance test at 1000 volts DC from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase.
3. Check the following applicable functions by primary current injection.
   Measure minimum long-time pickup when possible.
   Measure long-time delay at three (3) times long-time pickup current.
   Measure short-time pickup.
   Measure short-time delay at one and one-half (1-1/2) times short-time pickup current.
   Measure instantaneous pickup.
   Measure ground fault pickup.
   Measure ground fault delay at one and one-half (1-1/2) times ground fault pickup.
   Check trip unit reset operation.

C. Test Values:

1. Trip characteristics of breakers shall fall within the manufacturer's published time-current tolerance bands.

3.07 METERING

A. Visual and Mechanical Inspection:

1. Check all devices for physical damage and connection tightness.
2. Verify meter nameplate designation.

B. Electrical Tests:

1. Check calibration of all meter functions at zero, midscale and full scale deflections by transfer standard.

2. Check calibration of meters for proper registration by manufacturer's recommended method.
3. Verify instrument multipliers and scale factors.

3.08 PROTECTIVE RELAYS

A. Visual and Mechanical Inspection:

1. Inspect relays for physical damage, presence of foreign material, moisture, and corrosion.
2. Clean cover glass and relay components as required.
3. Check for freedom of movement, proper travel and alignment and tightness of mounting hardware and tap screws.

B. Electrical Tests:

1. Perform insulation resistance test on each circuit branch to frame.
2. Perform the following tests at the settings indicated in the study:
   Pickup parameters on each operating element.
   Timing at three (3) points on time characteristic curve.
   Pickup target and seal-in units.
   Special tests as required to check operation of restraint, directional, and other elements per manufacturer's instructions.
3. Perform functional test to assure relay contacts trip the associated breaker or auxiliary device.
4. Perform phase angle and magnitude contribution tests on differential and directional type relays after energization to vectorially prove proper polarity and connection.

C. Test Values:

1. Manufacturer’s tolerances shall be used to determine acceptability of results.

3.09 WIRING DEVICES

A. Visual and Mechanical Inspection:

1. Inspect relays for physical damage, presence of foreign material, moisture, and corrosion.
2. Clean cover glass and relay components as required.
3. Check for freedom of movement, proper travel and alignment and tightness of mounting hardware and tap screws.

B. Electrical Tests:

1. Perform wiring continuity test on each receptacle.
2. Perform ground fault interruption test on each GFI receptacle using external ground fault simulation testing equipment.

3.10 SYSTEM FUNCTION TESTS

A. General: Perform system function tests upon completion of equipment component tests as defined in this specification. It is the purpose of system function tests to prove the proper interaction of all sensing, processing, and action devices.

B. Implementation: Contractor is to notify the Engineer when system testing is to begin. Commissioning Agent shall provide to the Contractor a test procedures for the equipment and systems to be functionally tested. The test procedure shall be reviewed and approved by the Owner and Engineer 10 days prior to beginning the system testing.

END OF SECTION 26 08 00

Page Intentionally Left Blank

SECTION 26 24 16 PANELBOARDS

PART 1 - GENERAL

1.01 SCOPE

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes panelboards, overcurrent protective devices, and associated auxiliary equipment rated 600 V and less for the following types:

1. Lighting and appliance branch-circuit panelboards.

1.03 SUBMITTALS

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

B. Shop Drawings: For each panelboard and related equipment.

1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Enclosure types and details for types other than NEMA 250, Type 1.
b. Bus configuration, current, and voltage ratings.
c. Short-circuit current rating of panelboards and overcurrent protective devices.
d. UL listing for series rating of installed devices.
e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.

D. Field Test Reports: Submit written test reports and include the following:

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.

E. Panelboard Schedules: For installation in panelboards. Submit final versions.

F. Maintenance Data: For panelboards and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section " Closeout Procedures," 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.

1.04 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency that is a member company of the National Electrical Testing Association and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the National Electrical Testing Association or National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. 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.

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

1.05 COORDINATION

A. Coordinate layout and installation of panelboards and components with existing and other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturer: Panelboards shall be as manufactured by the same manufacturer selected for Switchgear specified in Section 26 24 13.

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

1. Eaton Corp.; Cutler-Hammer Products.
2. General Electric Co.
3. Westinghouse/Siemens/ITE
4. Square D Co.

2.02 FABRICATION AND FEATURES

A. Enclosures: Flush- and surface-mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.
1. Other Wet or Damp Locations: NEMA 250, Type 4.

B. Front: Entire front trim hinged (piano type hinge) to box and with standard hinged door within hinged trim cover and secured to box with screws. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.

C. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.

D. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door. (Panel schedules shall be typed and include device type and room(s) served).

E. Bus: Hard-drawn copper, 98 percent conductivity.

F. Main and Neutral Lugs: Mechanical type suitable for use with conductor material.

G. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.

H. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

I. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.

2.03 PANELBOARD SHORT-CIRCUIT RATING

A. Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.04 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

B. Doors: Front mounted with concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.05 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, with 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 250 A and larger.

B. Molded-Case Circuit-Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.

2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Mounting Heights: Top of trim 74 inches (1880 mm) above finished floor, unless otherwise indicated.

C. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

D. Circuit Directory: Create a directory to indicate installed circuit loads (Panel directories shall be typed and include device type and room(s) served). Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

E. Install filler plates in unused spaces.

F. Provision for Future Circuits at Flush Panelboards: Stub two 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.

G. Neatly train all wiring inside panels using nylon straps.

3.02 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 26 05 53 "Identification for Electrical."

B. Panelboard Nameplates: Label each panelboard with engraved laminated-plastic nameplate mounted with corrosion-resistant screws.

3.03 CONNECTIONS

A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.

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

3.04 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Testing Agency: Perform tests or engage a qualified independent testing agency to perform specified testing.

C. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. 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.

3.05 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 26 24 16

Page Intentionally Left Blank

SECTION 26 27 26 WIRING DEVICES

PART 1 - GENERAL

1.01 SCOPE

A. The CONTRACTOR shall furnish and install all wiring devices shown on the Drawings and as required for the electrical distribution systems.

B. Wiring devices shall include lighting switches, plug receptacles, multi-outlet assemblies, and miscellaneous wiring devices including cover plates and all other materials and accessories required for the complete wiring device installations as shown on the Drawings and as described in this Section.

1.02 REFERENCES

A. NEMA WD 1-83: General Requirements for Wiring Devices.

B. NEMA WD 6-88: Wiring Device – Dimensional Requirements.

C. UL 486A-91: Wire Connectors and Soldering Lugs for Use with Copper Conductors.

D. UL 20: General-Use Snap Switches.

E. UL 498: Electrical Attachment Plugs and Receptacles.

F. UL 943: Ground-Fault Circuit Interrupters.

1.03 SUBMITTALS

A. The CONTRACTOR shall submit drawings, data, and descriptive information in accordance with the requirements of this Section, Section 26 05 00 – Common Work Results for Electrical, and Section 01 33 00 – Submittal Procedures.

B. Samples:

1. Submit physical sample of each type of device used and device coverplate product samples to illustrate materials, equipment or workmanship, for color selection coordination and compliance with technical specifications

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Provide products specified in this Section that are “listed and labeled” (as defined by the National Electrical Code, Article 100).
2. Comply with NEMA WD 1. Comply with NFPA 70.

1.05 DEFINITIONS

A. GFCI: Ground-Fault Circuit Interrupter

1.06 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.

B. Cord and Plug Sets: Match equipment requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling, and Unloading: Deliver all materials to the Work site in original, new, and unopened containers bearing the manufacturer's name and label.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturers: Items of material furnished for the Work, subject to compliance with requirements, items listed or equal approved from manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Wiring Devices:

1. Bryant Electric, Inc.
2. Arrow-Hart
3. Eagle Electric Manufacturing Co., Inc.
4. GE Company; GE Wiring Devices.
5. Hubbell, Inc.; Wiring Devices Div.
6. Ilsco
7. Leviton Manufacturing Co., Inc.
8. Pass & Seymour/Legrand, Wiring Devices Div.
9. Lutron
10. Slater
11. Raceway Components, Inc. – for floor mounted service fittings
12. Wood Head – for cord drops

C. Multioutlet Assemblies:

1. Carlton
2. IsoDuct
3. Panduit
4. Pass & Seymour
5. Walker
6. Wiremold

D. Time Clocks:

1. Paragon
2. Tork

2.02 COMPONENTS

A. Straight-Blade Receptacles: 20-Ampere, Heavy-Duty grade, nylon, flat faced Comply with NEMA WD 6. Provide devices for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter.

Automatic Load Control Receptacles identified on the drawings for compliance with IECC – C405.11 shall be permanently marked, by the manufacturer, with the generic controlled receptacle symbol and the word “CONTROLLED” as well as be a different color as noted.

B. GFCI Receptacles: Specification Grade, nylon, flat faced, feed-through type, with integral NEMA WD 6 Configuration 5-20R duplex receptacle. Manufactured to protect connected downstream receptacles on same circuit (when downstream receptacles are located in the same room). Provide devices for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter.

C. Locking Receptacles: Heavy-Duty grade, Comply with NEMA WD 6. Provide devices for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter.

D. Multi-pole Contactors and Relays:

1. Description: Electrically operated and mechanically held and complying with UL 508 and NEMA ICS 2.
2. Current Rating for Switching: UL listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballasts with 15 percent or less total harmonic distortion of normal load current).
3. Control Coil Voltage: Match control power source.

E. Time Clocks: Solid-state programmable units with alphanumeric display complying with UL 917.

1. Description: Electronic astronomic type complying with UL 917.
2. Astronomic dial.
3. Two contacts rated 30 A at 277-V ac, unless otherwise indicated.
4. Two pilot-duty contacts rated 2 A at 240-V ac, unless otherwise indicated.
5. Eight-day program uniquely programmable for each weekday and holidays.
7. Skip-day mode.

F. Wall Plates: Single and combination types match corresponding wiring devices. Metal plate-securing screw with head color to match plate finish. Material for Finished Spaces: Nylon, color to match wiring devices, color to be white.

2.03 FINISHES

A. Color: Manufacturers white.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Secure all devices and assemblies plumb and secure

B. Arrange devices and assemblies, unless otherwise noted, mounted flush with long dimension vertical, and grounding terminal of receptacles on top.

C. Install wall dimming switches to achieve indicated ratings as noted on Drawings, after derating for ganging as instructed by manufacturer. Connect wiring to dimmer in accordance with manufacturer's installation instructions, do not share neutral conductor connected to load side of dimmers.

D. Provide adequate protection for devices and assemblies prior to commencement of painting. Install device wall plates and assembly cover plates upon completion of painting.

E. Connect wiring device and assembly grounding terminal to outlet box with bonding jumper. Connect wiring device and assembly grounding terminal to branch circuit conductors and equipment grounding wire with six inch wire pigtails.

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

3.02 IDENTIFICATION

A. Comply with Section 26 05 53 "Identification for Electrical"

B. For lighting control power packs located above accessible ceilings, provide typed labels on ceiling T-grid indicating the location of the device(s). Provide proper labeling "Power Pack", etc.

3.03 FIELD QUALITY CONTROL

A. Site Tests, Inspections:

1. Test wiring devices for proper polarity and ground continuity. Operate each device and assembly at least six times.
2. Test GFCI operation with both local and remote fault simulations in accordance with manufacturer's written testing procedures.

3.04 ADJUSTING

A. Replace damaged and/or defective components.

3.05 CLEANING

A. Keep all items protected before, during, and after installation. Clean area and remove all debris. Remove all paint overspray and/or spattering from devices and assemblies.

3.06 DEMONSTRATION

A. The Contractor shall provide for demonstration and complete instruction to the Owners' operating personnel as to the operation, maintenance, and repair procedures of all installed devices and assemblies.

END OF SECTION 26 27 26

Page Intentionally Left Blank

SECTION 26 28 16 ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 SCOPE

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.

1.02 SUMMARY

A. Section Includes: This section includes requirements for individually mounted and enclosed fused and non-fused disconnect switches, fuses, and circuit breakers for disconnecting and protecting services, feeders, branch circuits, and utilization equipment.

1.03 REFERENCES

A. The latest edition of the following standards and codes, standard publications of professional organizations, and the local authorities having jurisdiction are the minimum requirements for this work.

1. American National Standards Institute (ANSI)
2. Institute of Electrical and Electronic Engineers (IEEE)
3. National Electrical Manufacturer's Association (NEMA)
4. National Fire Protection Association (NFPA)
5. NFPA 70, the National Electrical Code (NEC-latest edition)
6. Underwriters Laboratories, Inc. (UL)
7. State, city, and local authorities

1.04 SUBMITTALS

A. General:

1. Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data for disconnect switches, circuit breakers, and accessories specified in this section as follows:

1. Descriptive data and ratings for voltage, continuous current, maximum horsepower, and short-circuit rating.
2. Dimensional plans, elevations, sections, and details.
3. NEMA enclosure type and size.
4. Cable terminal size, number, and material.
5. Unit wiring diagrams depicting local and remote devices.

6. Accessories device descriptive bulletins and product data sheets (i.e., shunt trip coil, undervoltage release, ground fault, auxiliary contacts, key interlocks, etc.).

C. Spare Parts: Provide 10% (minimum of 3 fuses) spare fuses for each fuse rating and type used on the project.

1.05 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, the National Electrical Code (latest edition).

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Disconnect Switches and Circuit Breakers: Acceptable manufacturers are listed below. All disconnect and circuit breakers shall be of the same manufacturer as Switchgear and Panelboards.

1. Eaton Corp.; Cutler-Hammer
2. General Electric Co.
3. Westinghouse/Siemens/ITE
4. Square D Company

B. Fuses: Acceptable manufacturers are listed below. All fuses shall be of the same manufacturer.

1. Bussman
2. Gould Shamut
3. Littlefuse

2.02 DISCONNECT SWITCHES

A. Enclosed fusible and non-fusible switches, 1200-amp and smaller, NEMA KS1, heavy duty type with cover and externally accessible lockable handle, 600-volts, horsepower rated for motors as required. Number of poles and ampacity as noted or required by code. Short-circuit rating shall be sufficient to withstand the available fault current or let-through current before the fuse melts without damage or change in rating.

B. Fusible switches 30- through 600-amperes shall be furnished with rejection class "R" or "J" type fuse clips and 800 through 1200 amperes shall be furnished with class "L" type fuse clips.

C. Switches shall incorporate a safety cover interlock to prevent opening the cover with the switch in the "ON" position or prevent placing the switch in the "ON" position with the cover open. Provide a “defeater” for authorized personnel.

D. Handles shall have provisions for padlocking and shall clearly indicate the ON and OFF positions. Front cover doors shall be padlockable in the closed position.

2.03 FUSES

A. Fuses shall be Class K-1 and K-5 of rejection type for 600 amperes and below and Class L for over 600 amperes. Fuse voltage class shall be either 250 volt or 600 volt and shall be applied according to circuit voltage.

B. Coordinate the low-voltage fuses required for the project to provide basic selective protection and properly coordinate with the other associated protective equipment.

2.04 CIRCUIT BREAKERS

A. General:

1. Provide 600-volt enclosed molded case circuit breaker per NEMA AB1 with lockable handle with frame size, trip rating, number of poles, and interrupting rating to meet available fault current. Application listing shall be appropriate for switching fluorescent lighting loads or heating, air conditioning, and refrigerating equipment.
2. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-breaker over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be nonwelding silver alloy and arc extinction shall be accomplished by means of arc chutes.
3. Thermal-magnetic Circuit Breakers: Frame sizes 400 amp and smaller shall have inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits.
4. Adjustable Instantaneous-trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
5. Electronic Trip Unit Circuit Breakers: Frame sizes 600 amp and larger shall have RMS sensing; field-replaceable rating plug; with the following field-adjustable settings as noted on the drawings by L, S, I, and G.
   a. Instantaneous trip
   b. Long- and short-pickup levels
   c. Long- and short-time adjustments
   d. Ground-fault pickup level, time delay, and I^2t response
6. Current-limiting Circuit Breakers: Frame sizes 400 amp and smaller; let-through ratings less than NEMA FU 1, RK-5.
7. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity for personal protection and 30 mA trip sensitivity for equipment protection.
8. Molded-case Switch: Molded-case circuit breaker without trip units.

B. Circuit-breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Mechanical style suitable for number, size, and material of conductors.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
3. Ground-fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
4. Shunt Trip: 120-volt trip coil energized from separate circuit.

2.05 ENCLOSURE

A. NEMA 1 to meet environmental conditions of installed location.

1. Outdoor Locations: NEMA 250, Type 3R.
2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7 for Class I Group A, B, C, or D.
5. Hazardous Areas Indicated on Drawings: NEMA 250, Type 9 for Class II Group E, F, or G.
6. Indoor use for protection against dust, falling dirt, and dripping non-corrosive liquids; NEMA 250, Type 12

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install devices in general area of equipment and accessible to maintenance personnel according to manufacturer's written instructions. Secure devices firmly to supporting structure with approved fasteners in a level and plumb manner. Verify voltage and amperage size and enclosure type of devices for each installation. Where practical, devices shall be mounted such that the top of switch is a maximum of 6'-0" above finished floor or surface.

B. Connect devices to wiring system and to ground as indicated and instructed by manufacturer.

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

C. Identify each device according to requirements in other sections of these specifications.

3.02 OVERCURRENT PROTECTIVE DEVICES

A. Install fuses where required as a protective device in conformance with equipment manufacturer's specified requirements and in accordance with the requirements of this section.

3.03 EQUIPMENT CONNECTIONS

A. Provide all final power connections for mechanical equipment. Confirm with suppliers all rough-in data, e.g., electrical characteristics, dimensions, locations, type of connection, etc., prior to installation.

3.04 FUSE CABINET

A. Surface-mounted steel fuse cabinet shall be wall-mounted in the main electrical room and have a hinged front door and a flush catch with lock (panelboard type). The cabinet shall contain the spare fuses of each size and type used in the project. On front of hinged door, provide an engraved nameplate with black letters and white phenolic material screwed in place reading, "Spare Fuses."

3.05 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
2. Test continuity of each line- and load-side circuit.
3. Perform visual and mechanical inspection.
4. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.06 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.07 CLEANING

A. On completion of installation, inspect interior and exterior of enclosures. Remove paint and plaster splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 26 28 16

Page Intentionally Left Blank

SECTION 26 56 68 EXTERIOR ATHLETIC LIGHTING & CONTROLS

PART 1 - GENERAL

1.01 SUMMARY

A. Work covered by this section of the specifications shall conform to the contract documents, engineering plans as well as state and local codes.

B. The purpose of these specifications is to define the lighting system performance and design standards for three City of Thornton Skate Parks using an LED Lighting source. The manufacturer / contractor shall supply lighting equipment to meet or exceed the standards set forth in these specifications.

C. The sports lighting will be for the following venues:

1. ~~Margaret W Carpenter Park~~
2. Thomas J. Slocum Community Park
3. ~~Trailwinds Recreation Center Park~~

D. The primary goals of this sports lighting project are:

1. Guaranteed Light Levels: Selection of appropriate light levels impact the safety of the skaters and the enjoyment of spectators. Therefore. light levels are guaranteed to not drop below specified target values for a period of 25 years.
2. Environmental Light Control: It is the primary goal of this project to minimize spill light to adjoining properties and glare to the skaters, spectators, and neighbors.
3. Cost of Ownership: In order to reduce the operating budget, the preferred lighting system shall be energy efficient and cost effective to operate. All maintenance costs shall be eliminated for the duration of the warranty.
4. Control and Monitoring: To allow for optimized use of labor resources and avoid unneeded operation of the facility, customer requires a remote on/off control system for the lighting system. Skate Parks should be proactively monitored to detect luminaire outages over a 25-year life cycle. All communication and monitoring costs for 25-year period shall be included in the bid.

1.02 LIGHTING PERFORMANCE

A. Illumination Levels and Design Factors: Skating surfaces shall be lit to an average target illumination level and uniformity as specified in the chart below. Lighting calculations shall be developed, and field measurements taken on the grid spacing with the minimum number of grid points specified below. Appropriate light loss factors shall be applied and submitted for the basis of design. Average illumination level shall be measured in accordance with the IESNA LM-5-04 (IESNA Guide for Photometric Measurements of Area and Sports Lighting Installations). Illumination levels shall not to drop below desired target values in accordance to IES RP-6-15, Page 2, Maintained Average Illuminance and shall be guaranteed for the full warranty period.

Area of Lighting	Average Target Illumination Levels	Maximum to Minimum Uniformity Ratio	Grid Points	Grid Spacing
Slocum Memorial Skate Park	25fc	3:1	250	10' x 10'
Trail Winds Skate Park	~~25fc~~	~~2.7:1~~	~~211~~	~~10' x 10'~~
Carpenter Skate Park	~~25fc~~	~~2.5:1~~	~~127~~	~~10' x 10'~~

B. Color: The lighting system shall have a minimum color temperature of 5700K and a CRI of 75.

C. Mounting Heights: To ensure proper aiming angles for reduced glare and to provide better playability, minimum mounting heights shall be as described below. Higher mounting heights may be required based on photometric report and ability to ensure the top of the court angle is a minimum of 10 degrees below horizontal.

Location	# of Poles	Pole Designation	Pole Height
~~Carpenter Park~~	~~5~~	~~P1-P5~~	~~50'~~
Community Park	4	P1-P4	50'
~~Trailwinds Park~~	~~4~~	~~P1-P4~~	~~50'~~

1.03 ENVIRONMENTAL LIGHT CONTROL

A. Light Control Luminaires: All luminaires shall utilize spill light and glare control devices including, but not limited to, internal shields, louvers and external shields. No symmetrical beam patterns are accepted.

1.04 SUBMITTALS

A. The CONTRACTOR shall submit drawings, data, and descriptive information in accordance with the requirements of this Section, Section 26 05 00 – Common Work Results for Electrical, and Section 01 30 00 –Submittal Procedures.

B. Product Data: For each type of lighting equipment.
1. Arrange in order of luminaire or pole designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of the luminaires.
4. LED driver, including power factor, THD, UL listing and recognition, ANSI certification, and Energy Independence and Security Act of 2007 compliance.
5. LED boards and/or chips (lumens, CCT, and CRI), and wattage.
6. Photometric data and adjustment factors based on laboratory tests, complying with IES "Lighting Measurements Testing and Calculation Guides," of each lighting luminaire type. The adjustment factors shall be for LEDs, drivers, and

accessories identical to those indicated for the luminaire as applied in this Project.

C. Delegated-Design Submittal: For exterior athletic lighting indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings and specifications for construction of lighting system.
2. Manufacturer's determination of LLF used in design calculations.
3. Lighting system design calculations for the following:
    a. Target illuminance.
    b. Point calculations of horizontal and vertical illuminance, CV, and UG at minimum grid size and area.
    c. Point calculations of horizontal and vertical illuminance in indicated areas of concern for spill light.
    d. Calculations of source intensity of luminaires observed at eye level from indicated properties near the skate parks.
4. Electrical system design calculations for the following:
    a. Total connected and estimated peak-demand electrical load, in kilowatts, of lighting system.
    b. Capacity of feeder required to supply lighting system.
5. Wiring requirements, including required conductors, cables, and wiring methods.
6. Structural analysis data and calculations used for pole selection.
    a. See the Evaluations for discussion about manufacturer's certifications for complying with AASHTO.
    b. Manufacturer Wind-Load Strength Certification: Submit certification that selected total support system, including poles, complies with AASHTO LTS-6-M for location of Project.
7. Cost of Ownership
    a. Manufacturer shall submit a 25 year Cost of Ownership summary that includes energy consumption, anticipated maintenance costs, and control costs. All costs associated with faulty luminaire replacement - equipment rentals, removal and installation labor, and shipping - are to be included in the maintenance costs.

PART 2 - PRODUCT

2.01 SPORTS LIGHTING SYSTEM CONSTRUCTION

A. Manufacturing Requirements: All components shall be designed and manufactured as a system. All luminaires, wire harnesses, drivers and other enclosures shall be factory assembled, aimed, wired, and tested.

B. Durability: All exposed components shall be constructed of corrosion resistant material and/or coated to help prevent corrosion. All exposed carbon steel shall be hot dip galvanized per ASTM A123. All exposed aluminum shall be powder coated with high performance polyester or anodized. All exterior reflective inserts shall be anodized, coated, and protected from direct environmental exposure to prevent

reflective degradation or corrosion. All exposed hardware and fasteners shall be stainless steel, passivated and coated with aluminum-based thermosetting epoxy resin for protection against corrosion and stress corrosion cracking. Structural fasteners may be carbon steel and galvanized meeting ASTM A153 and ISO/EN 1461 (for hot dipped galvanizing), or ASTM B695 (for mechanical galvanizing). All wiring shall be enclosed within the cross-arms, pole, or electrical components enclosure.

C. System Description: Lighting system shall consist of the following:

1. Galvanized steel poles and cross-arm assembly.
2. Non-approved pole technology:
    a. Square static cast concrete poles will not be accepted.
    b. Direct bury steel poles which utilize the extended portion of the steel shaft for their foundation will not be accepted due to potential for internal and external corrosive reaction to the soils and long term performance concerns.
3. Lighting systems shall use concrete foundations. See Section 2.4 for details.
    a. For a foundation using a pre-stressed concrete base embedded in concrete backfill the concrete shall be air-entrained and have a minimum compressive design strength at 28 days of 3,000 PSI. 3,000 PSI concrete specified for early pole erection; actual required minimum allowable concrete strength is 1,000 PSI. All piers and concrete backfill must bear on and against firm undisturbed soil.
    b. For anchor bolt foundations or foundations using a pre-stressed concrete base in a suspended pier or reinforced pier design pole erection may occur after 7 days. Or after a concrete sample from the same batch achieves a certain strength.
4. Manufacturer will supply all drivers and supporting electrical equipment
    a. Remote drivers and supporting electrical equipment shall be mounted approximately 10 feet above grade in aluminum enclosures. The enclosures shall be touch-safe and include drivers and fusing with indicator lights on fuses to notify when a fuse is to be replaced for each luminaire. Disconnect per circuit for each pole structure will be located in the enclosure. Integral drivers are not allowed.
    b. Manufacturer shall provide surge protection at the pole equal to or greater than 40 kA for each line to ground (Common Mode) as recommended by IEEE C62.41.2_2002.
5. Wire harness complete with an abrasion protection sleeve, strain relief and plug-in connections for fast, trouble-free installation.
6. All luminaires, visors, and cross-arm assemblies shall withstand 150 mi/h winds and maintain luminaire aiming alignment.
7. Control cabinet to provide remote on-off control and monitoring of the lighting system. See Section 2.3 for further details.
8. Manufacturer shall provide lightning grounding as defined by NFPA 780 and be UL Listed per UL 96 and UL 96A.
    a. Integrated grounding via concrete encased electrode grounding system.
    b. If grounding is not integrated into the structure, the manufacturer shall supply grounding electrodes, copper down conductors, and exothermic

weld kits. Electrodes and conductors shall be sized as required by NFPA 780.The grounding electrode shall be minimum size of 5/8 inch diameter and 8 feet long, with a minimum of 10 feet embedment. Grounding electrode shall be connected to the structure by a grounding electrode conductor with a minimum size of 2 AWG for poles with 75 feet mounting height or less, and 2/0 AWG for poles with more than 75 feet mounting height.

D. Safety: All system components shall be UL listed for the appropriate application.

2.02 ELECTRICAL

A. Electric Power Requirements for the Sports Lighting Equipment:

1. Electric power: 208 Volt, 3 Phase.
2. Maximum total voltage drop: Voltage drop to the disconnect switch located on the poles shall not exceed three (3) percent of the rated voltage.

B. Energy Consumption: The kW consumption for the court lighting system shall not exceed 8kW.

2.03 CONTROL

A. Instant On/Off Capabilities: System shall provide for instant on/off of luminaires. The control system shall be placed on a timer with manual ON push buttons. Users are able to turn ON the lights and the timer will turn off the lights at a time determined by Owner.

B. Lighting contactor cabinet(s) constructed of NEMA Type 4 aluminum, designed for easy installation with contactors, labeled to match field diagrams and electrical design. Manual off-on-auto selector switches shall be provided and located on the inside of the enclosure.

C. Dimming: System shall provide for 3-stage dimming (high, medium, low). Dimming will be set via scheduling options (Website, app, phone, fax, email).

D. Remote Lighting Control System: System shall allow owner and users with a security code to schedule on/off system operation via a web site, phone, fax or email up to ten years in advance. Manufacturer shall provide and maintain a two-way TCP/IP communication link. Trained staff shall be available 24/7 to provide scheduling support and assist with reporting needs.

The owner may assign various security levels to schedulers by function and/or skate parks. This function must be flexible to allow a range of privileges such as full scheduling capabilities for all skate parks to only having permission to execute “early off” commands by phone. Scheduling tool shall be capable of setting curfew limits.

Controller shall accept and store 7-day schedules, be protected against memory loss during power outages, and shall reboot once power is regained and execute any commands that would have occurred during outage.

E. Remote Monitoring System: System shall monitor lighting performance and notify manufacturer if individual luminaire outage is detected so that appropriate maintenance can be scheduled. The controller shall determine switch position (manual or auto) and contactor status (open or closed).

F. Management Tools: Manufacturer shall provide a web-based database and dashboard tool of actual court usage and provide reports by facility and user group. Dashboard shall also show current status of luminaire outages, control operation and service. Mobile application will be provided suitable for IOS and devices.

Hours of Usage: Manufacturer shall provide a means of tracking actual hours of usage for the court lighting system that is readily accessible to the owner.

1. Cumulative hours: shall be tracked to show the total hours used by the facility
2. Report hours saved by using early off and push buttons by users.

G. Communication Costs: Manufacturer shall include communication costs for operating the control and monitoring system for a period of 25 years.

H. Communication with luminaire drivers: Control system shall interface with drivers in electrical components enclosures by means of powerline communication.

2.04 STRUCTURAL PARAMETERS

A. Wind Loads: Wind loads shall be based on the 2021 International Building Code. Wind loads to be calculated using ASCE 7-10, an ultimate design wind speed of 120mph and exposure category C.

B. Pole Structural Design: The stress analysis and safety factor of the poles shall conform to 2013 AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals (LTS-6).

C. Foundation Design: The foundation design shall be based on soil parameters as outlined in the geotechnical report. If no geotechnical report is available, the foundation design shall be based on soils that meet or exceed those of a Class 5 material as defined by 2021 IBC Table 1806.2.

D. Foundation Drawings: Project specific foundation drawings stamped by a registered engineer in the state where the project is located are required. The foundation drawings must list the moment, shear (horizontal) force and axial (vertical) force at ground level for each pole.

PART 3 - EXECUTION

3.01 SOIL QUALITY CONTROL

A. It shall be the Contractor’s responsibility to notify the Owner if soil conditions exist other than those on which the foundation design is based, or if the soil cannot be

readily excavated. Contractor may issue a change order request / estimate for the Owner’s approval / payment for additional costs associated with:

1. Providing engineered foundation embedment design by a registered engineer in the State of Colorado for soils other than specified soil conditions.
2. Additional materials required to achieve alternate foundation.
3. Excavation and removal of materials other than normal soils, such as rock, caliche, etc.

3.02 DELIVERY TIMING

A. Delivery Timing Equipment On-Site: The equipment must be on-site 10-12 weeks from receipt of approved submittals and receipt of complete order information.

3.03 FIELD QUALITY CONTROL

A. Illumination Measurements: Upon substantial completion of the project and in the presence of the Contractor, Project Engineer, Owner's Representative, and Manufacturer's Representative, illumination measurements shall be taken and verified. The illumination measurements shall be conducted in accordance with IESNA LM-5-04.

B. Skate Park Light Level Accountability

1. Light levels are guaranteed not to fall below the target maintained light levels for the entire warranty period of 25 years. These levels will be specifically stated as “guaranteed” on the illumination summary provided by the manufacturer.
2. The contractor/manufacturer shall be responsible for conducting initial light level testing and an additional inspection of the system, in the presence of the owner, one year from the date of commissioning of the lighting.
3. The contractor/manufacturer will be held responsible for any and all changes needed to bring these skate parks back to compliance for light levels and uniformities. Contractor/Manufacturer will be held responsible for any damage to the other landscape areas disturbed during these repairs.

C. Correcting Non-Conformance: If, in the opinion of the Owner or his appointed Representative, the actual performance levels including footcandles and uniformity ratios are not in conformance with the requirements of the performance specifications and submitted information, the Manufacturer shall be required to make adjustments to meet specifications and satisfy Owner.

3.04 WARRANTY AND GUARANTEE

A. 25-Year Warranty: Each manufacturer shall supply a signed warranty covering the entire system for 25 years from the date of shipment. Warranty shall guarantee specified light levels. Manufacturer shall maintain specifically-funded financial reserves to assure fulfillment of the warranty for the full term. Warranty does not cover weather conditions events such as lightning or hail damage, improper

installation, vandalism or abuse, unauthorized repairs or alterations, or product made by other manufacturers.

B. Maintenance: Manufacturer shall monitor the performance of the lighting system, including on/off status, hours of usage and luminaire outage for 25 years from the date of equipment shipment. Parts and labor shall be covered such that individual luminaire outages will be repaired when the usage of any court is materially impacted. Manufacturer is responsible for removal and replacement of failed luminaires, including all parts, labor, shipping, and equipment rental associated with maintenance. Owner agrees to check fuses in the event of a luminaire outage.

3.05 PRE-BID SUBMITTAL REQUIREMENTS

A. Design Approval: The owner / engineer will review pre-bid submittals per section 3.5.B from all the manufacturers to ensure compliance to the specification 10 days prior to bid. If the design meets the design requirements of the specifications, a letter and/or addendum will be issued to the manufacturer indicating approval for the specific design submitted.

B. Approved Product: Musco's Light-Structure SystemTM with TLC for LEDTM is the approved product. All substitutions must provide a complete submittal package for approval as outlined in Submittal Information at the end of this section at least 10 days prior to bid. Special manufacturing to meet the standards of this specification may be required. An addendum will be issued prior to bid listing any other approved lighting manufacturers and designs.

C. All listed manufacturers not pre-approved shall submit the information at the end of this section at least 10 days prior to bid. An addendum will be issued prior to bid; listing approved lighting manufacturers and the design method to be used.

D. Bidders are required to bid only products that have been approved by this specification or addendum by the owner or owner's representative. Bids received that do not utilize an approved system/design, will be rejected.

END OF SECTION 26 56 68

REQUIRED SUBMITTAL INFORMATION FOR ALL MANUFACTURERS
(NOT PRE-APPROVED)
10 DAYS PRIOR TO BID

All items listed below are mandatory, shall comply with the specification and be submitted according to pre-bid submittal requirements. Complete the Yes/No column to indicate compliance (Y) or noncompliance (N) for each item. Submit checklist below with submittal.

Yes / No	Tab	Item	Description
	A	Letter/ Checklist	Listing of all information being submitted must be included on the table of contents. List the name of the manufacturer's local representative and his/her phone number. Signed submittal checklist to be included.
	B	Equipment Layout	Drawing(s) showing Skate Park layouts with pole locations
	C	On Court Lighting Design	Lighting design drawing(s) showing: a. Skate Park Name, date, file number, prepared by b. Outline of skate park(s) being lighted, as well as pole locations referenced to the center of the court (x & y), Illuminance levels at grid spacing specified c. Pole height, number of fixtures per pole, horizontal and vertical aiming angles, as well as luminaire information including wattage, lumens and optics d. Height of light test meter above skate park surface. e. Summary table showing the number and spacing of grid points; average, minimum and maximum illuminance levels in foot candles (fc); uniformity including maximum to minimum ratio, coefficient of variance (CV), coefficient of utilization (CU) uniformity gradient; number of luminaries, total kilowatts, average tilt factor; light loss factor.
	D	Off Court Lighting Design	Lighting design drawing showing initial spill light levels along the boundary line (defined on bid drawings) in footcandles. Lighting design showing glare along the boundary line in candela. Light levels shall be taken at 30-foot intervals along the boundary line. Readings shall be taken with the meter orientation at both horizontal and aimed towards the most intense bank of lights.
	E	Photometric Report	Provide first page of photometric report for all luminaire types being proposed showing candela tabulations as defined by IESNA Publication LM-35-02. Photometric data shall be certified by laboratory with current National Voluntary Laboratory Accreditation Program or an independent testing facility with over 5 years' experience.
	F	Performanc e Guarantee	Provide performance guarantee including a written commitment to undertake all corrections required to meet the performance requirements noted in these specifications at no expense to the owner. Light levels must be guaranteed to not fall below target levels for warranty period.
	G	Structural Calculations	Pole structural calculations and foundation design showing foundation shape, depth backfill requirements, rebar and anchor bolts (if required). Pole base reaction forces shall be shown on the foundation drawing along with soil bearing pressures. Design must be stamped by a structural engineer in the state of Colorado, if required by owner. (May be supplied upon award).

	H	Control & Monitoring System	Manufacturer of the control and monitoring system shall provide written definition and schematics for automated control system. They will also provide ten (10) references of customers currently using proposed system in the state of Colorado.
	I	Electrical Distribution Plans	Manufacturer bidding an alternate product must include a revised electrical distribution plan including changes to service entrance, panels and wire sizing, signed by a licensed Electrical Engineer in the state of Colorado.
	J	Warranty	Provide written warranty information including all terms and conditions. Provide ten (10) references of customers currently under specified warranty in the state of Colorado.
	K	Project References	Manufacturer to provide a list of ten (10) projects where the technology and specific fixture proposed for this project has been installed in the state of Colorado. Reference list will include project name, project city, installation date, and if requested, contact name and contact phone number.
	L	Product Information	Complete bill of material and current brochures/cut sheets for all products being provided.
	M	Delivery	Manufacturer shall supply an expected delivery timeframe from receipt of approved submittals and complete order information.
	N	Non-Compliance	Manufacturer shall list all items that do not comply with the specifications. If in full compliance, tab may be omitted.
	O	Cost of Ownership	Document cost of ownership as defined in the specification. Identify energy costs for operating the luminaires. Maintenance cost for the system must be included. All costs should be based on 25 Years

The information supplied herein shall be used for the purpose of complying with the specifications for City of Thornton's three Skate Parks. By signing below, I agree that all requirements of the specifications have been met and that the manufacturer will be responsible for any future costs incurred to bring their equipment into compliance for all items not meeting specifications and not listed in the Non-Compliance section.

Manufacturer: _____ Signature: _____

Contact Name: _____ Date: _____/_____/_____

Contractor: _____ Signature: _____

SECTION 32 84 00 PLANTING IRRIGATION

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Underground Sprinkler System.

B. Installation.

C. Testing.

D. Winterization and Spring Start-up.

E. Irrigation Audit.

1.02 RELATED SECTIONS AND DOCUMENTS

A. Drawings and General and Special Conditions of the Contract, including Division One and City of Thornton Standards and Specifications for the Design and Construction of Public and Private Improvements and other related specification sections apply to work of this section.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications: Provide underground sprinkler system as a complete unit produced by acceptable manufacturers indicated on drawings, including heads, valves, piping circuits, controls and accessories.

B. Installer Qualifications: Have satisfactorily installed acceptable underground sprinkler system(s) on at least three other projects of comparable complexity.

C. Irrigation Drawings: The irrigation drawings are essentially diagrammatic. Due to the scale of the drawings, all characteristics of the system (i.e., sleeving, fittings, etc.) may not be represented. The Contractor shall carefully inspect the site and plan the work accordingly, supplying any materials and equipment necessary to install said characteristics.

The Contractor shall notify Owner's Representative of any discrepancies of site dimensions, obstructions, etc. that were not shown on the drawings and that might not have been known during preparation of irrigation drawings. If such notification is not made, Contractor shall assume all expenses and responsibility for any revisions necessary. Work called for on the drawings by notes or on details shall be furnished and installed whether or not specifically mentioned in the specifications.

Design locations of heads, valves and lines are approximate. Contractor shall make minor adjustments of locations to avoid obstacles. Contractor to flag all head

locations and chalk all pipelines. Any adjustments or additional heads due to trees, lights, or other obstacles will be approved by Owner and Owner's Representative prior to any work. All finish grades shall be approved prior to installation of the irrigation system.

D. Ordinances and Regulations: Contractor shall observe all state and local laws, ordinances and regulations concerning the materials and installation of the irrigation system.

1.04 SUBMITTALS

A. As-Built or Record Drawings/Maintenance Manual: Acceptance of the system is based on the furnishing by the contractor of a complete red-line as-built plan showing exact location of all valves and any changes in location of sprinkler heads, piping, etc. which is acceptable to Design Concepts, the city's design consultant. Show locations of main connection, pressure lines, zone lines, all valves, additional wires, drip line blowout valves, changes in zoning, changes in numerical sequence at control valves, and other items required by Owner.

Contractor shall furnish two 11" x 17" reductions of the drawings, product cut-sheets and operation instructions for same, and complete maintenance instructions, including system winterization and start-up procedures, all neatly assembled in plastic sheet covers into one hard-cover three ring notebook with project name on cover. Also provide:

1. Two hose swivels with 3/4" adapters
2. Two valve box keys
3. Two gate valve keys, 6' length with tee handle.
4. Two sleeve locking cap keys
5. Two of each type of head installed on project
6. Two 1" quick coupler keys
7. Controller chart of as-built system to fit inside controller door. Identify area of coverage of each remote control valve, using a distinctly different pastel color drawing over entire area of coverage.

B. Quality Control Submittals: Any deviations from the proposed irrigation design must be approved by the Owner prior to construction. Submit three (3) copies of any design deviations before commencing any work.

C. As of the date of Initial Acceptance for the entire project, the Owner shall be solely responsible for setting of irrigation controllers. As part of the Initial Acceptance process, the Contractor shall provide in writing, the program of the existing irrigation settings, and any other information necessary to the proper operation of the irrigation system, if not already provided.

During the warranty period for the project, the Contractor may inspect the clock to review controller settings. If, as a result of a Contractor's inspection, it is determined that adjustments to those settings are necessary, the Contractor shall notify the

Owner, in writing, as to when the settings were inspected, what specific changes are recommended, and why.

The Contractor shall not make any changes to the irrigation settings during the warranty period.

If, in the opinion of the Owner, the changes are necessary, the Owner will make the changes to the clock and controller settings and notify the Contractor of the change. The Owner shall also notify the lContractor if the Owner determines that the recommended changes are not necessary and the basis for this determination.

If the Contractor makes any changes to the irrigation control settings during the warranty period, the Contractor assumes full financial responsibility for any damage and loss that occurs as a result of those changes.

1.05 GUARANTEE

A. Guarantee: During the period of one full year after Initial Acceptance, make all necessary repairs or replacements due to defective workmanship or materials within two (2) calendar days of receipt of notice of malfunction by the Owner. Any unwatered area due to poor placement or insufficient number of heads to be corrected by the Contractor.

1.06 PROTECTION OF PROPERTY AND SAFETY MEASURES

A. Property and Utilities: All trees, shrubs, flowers, fences, buildings, walks, roadways, and other property shall be protected from damage. Any damage to said property shall be repaired or replaced to the Owner's satisfaction at the Contractor's expense. Open trenches left exposed shall be flared and barricaded as per OSHA regulations by the Contractor. Contractor shall restore all areas to their original condition. Contractor shall be responsible to contact utility companies and the Owner's representative for staked locations of all utilities on the property. If staked utilities are damaged by the Contractor, the utilities shall be repaired at the Contractor's expense.

All trenching and other work within dripline of existing trees shall be done by hand so as not to damage tree roots or limbs. All trenches shall be no less than one foot from the trunk of any tree. Promptly notify Owner's Representative of unexpected sub-surface conditions.

B. Replacement of Paving and Curbs: Damage caused by trenching, crossing existing and/or proposed roadways, paths, curbing, etc. shall be kept to a minimum and all damaged areas shall be restored to their original condition. This will include compaction of subgrade to 95% relative compaction.

Restoration shall take the following course:

Match existing paving sections for asphalt paving. Thoroughly compact sub-base, base course, and bituminous course, matching grade of existing paving. No rough or rolled grades will be allowed.

Blacktop curbs - hot mix bituminous curb mix tamped and shaped to match adjoining curbs.

Concrete paving - concrete to match adjoining concrete work, with expansion joints.

Sidewalks - concrete to match adjoining concrete work.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, those specified on drawings.

2.02 MATERIALS

A. Main Lines: All lines under continuous pressure shall be PVC as indicated.
   1. Mainline Pipe: Shall be Polyvinylchloride (PVC) pipe, bell end, ASTM D2241 or commercial standard C5256, Type 1, normal impact, Class 200 or schedule 40 as applicable. It shall be continuously and permanently marked as to grade and manufacturer. 3" PVC or larger mainline shall be ring-tite, rubber-gasketed pipe and Leemco restrained fittings for mainline.
   2. PVC Fittings: Schedule 40 molded, solvent weld type PVC, or schedule 80 PVC if threaded.
   3. Solvent: Primer/Cleaner and heavy bond cement conforming to ASTM D-2564.

B. Branch Lines: All lines not under continuous pressure shall be PVC as indicated on drawings.
   1. Polyvinylchloride (PVC) Pipe: Must meet requirements as set forth in commercial standard CS256, Type 1, or ASTM D2241, schedule 40 as applicable.
   2. Joints: Plastic pipe joints shall be molded as the pipe and shall be suitable for solvent weld.
   3. Fittings: Plastic pipe fittings shall meet all the requirements of ASTM D2241 for Type 1, Grade PVC. Pressure rating and types of pipes shall be compatible with the pipe being used.
   4. Solvent: Primer/Cleaner and heavy bond cement conforming to ASTM D-2564.
   5. All piping to be lavender color to indicate non-potable water supply, see drawings.

C. Sleeving Pipe: Class 200 PVC. Sleeves to be at least 2 pipe sizes larger than line carried. Wiring shall be sleeved separately in 2" minimum pipe.

D. Valves: Manufacturer's standard, of type and size indicated, and as follows:

1. Electric Control Valves: In-line with manual flow adjustment. Include Pressure regulator and gauge (if specified). Brand valve box cover with SV # and corresponding zone on time clock with 1" minimum letters.
2. Key operated mainline valves: Manual main resilient seated valve, gate type, with square operating nut top. Brand valve box covers with 'GV' in 1" min. letters containing gate valves.
3. P.V.C. Swing Joints: Install quick couplers and rotary heads on P.V.C. double swing joints. Assemble by using three (3) schedule 80 elbows and four (4) schedule 80 nipples (3-3" nipples and 1-12" nipple). The male threaded nipples need to be wrapped with teflon tape. Optional Lasco or Dura prefabricated swing joints are also acceptable. No swing joints on control valves.

E. Sprinkler Heads:
   1. Hi Pop-up Spray Heads:
      a. Body: Stainless steel.
      b. Nozzle: plastic
      c. Stainless steel nozzle-adjustment screws.
      d. Positive stainless steel spring retraction.
      e. Pop-up projection shall be no less than 6". 12" minimum for shrub, flower, native seed and ground cover areas.
   2. Pop-up Rotary Gear Driven Heads:
      a. Body: High impact plastic.
      b. Drive: Sealed, oil packed gear assembly.
      c. Cover: rubber cover kit.
      d. Stainless steel retraction spring.
      e. Adjustable radius and full 360 radius.
      f. Stainless steel riser.

F. Quick Coupling Assemblies:
   1. Quick Coupling Valves: 2-piece all brass construction with locking rubber covers. Mounted in valve box as shown. Brand in 1" min. letters 'QC' on valve box cover containing quick coupler.
   2. Coupler Keys:
      a. Provide coupler keys and hose swivels for each site as noted in this specification.
      b. Brass construction, heavy duty, double lug type.

G. Valve Box: Highline with locking cover, per city detail. Use jumbo boxes for all 1-1½” control valves, Super Jumbo Box for 2” valves and Super Jumbo Box with the ball valve in a separate Standard Box for 3”+ valves.

H. Drainage Backfill: Clean, washed ¾” crushed granite. Seal completely in geotextile wrap. Allow no contact with soil!

I. Automatic Controller

   A. General: Furnish low voltage system manufactured expressly for control of automatic circuit valves of underground sprinkler systems. Provide unit of

capacity to suit number of circuits as indicated; connect to 120 power source provided by owner.

B. 110/120V electrical work shall be performed by a licensed Master Electrician and meet local code, Xcel Energy requirements and the NEC.

C. Switch Box: Supply separate 3 amp fuse box w/sp switch on locking Handy box and 6 amp fuse.

D. Power Surge Protection: Provide adequate lightning protection to prevent loss of circuit panels during electrical storms. Ground box to 5 ohm resistance as measured with a megger.

E. Exterior Control Enclosures: Manufacturer's standard with locking cover, complying with NFPA 70. Provide an outside breaker close to controller/meter, a disconnect switch and 120 Volt GFIC receptacle within pedestal as shown on drawings..

F. Transformer: To convert building service voltage to control voltage of 24 volts (included within controller).

G. Circuit Control: Each circuit variable from approximately 2 to 60 minutes. Include switch for manual or automatic operation of each circuit.

H. Timing Device: Adjustable, 24-hour and 7- or 14-day clocks to operate any time of day and skip any day in a 7- or 14-day period.

1. Allow for manual or semi-automatic operation without disturbing preset automatic operation.

I. Weather Sensor: Provide rain/freeze sensor as specified. Final location of sensor to be verified in the field with Owner.

J. Grounding: Providing grounding in accordance with manufacture’s specifications.

K. Control Wiring: Bury control wiring between controller and electric valves in sprinkler mainline trenches.

PART 3 - EXECUTION

3.01 SYSTEM DESIGN

A. Design Pressures: As indicated on Drawings, at connection to main pipe and at last head in circuit. Contractor to verify existing pressure prior to starting work.

B. Location of Heads: Design location is approximate. Make minor adjustments as necessary to avoid plantings and other obstructions. Flag head locations for approval before installation.

C. Minimum Water Coverage:
   1. Turf Areas: 100% minimum
   2. Other Planting Areas: 100% or as indicated.

3.02 TRENCHING AND BACKFILLING

A. General: Excavate straight and true with bottom uniformly sloped to low points. 3"/100' run to drain valve. Pipe should be snaked in trenches to allow for expansion and contraction. Chalk all areas to be trenched for approval before excavation.

B. Trench Depth: Excavate trenches to a depth of invert of pipe, unless otherwise indicated.
   1. Mainline Piping: 24" to top of pipe
   2. Lateral Piping: 18" to top of pipe (sprays and rotors)

C. Installation of Piping Under Paving: Contractor is to match and install new paving and base with existing paving and base where cutting of paving is necessary for installation of piping.

   Any cracking or breaking of pavement is to be repaired at Contractor's expense.

D. Backfill: Backfill with clean material from excavation. Remove organic material as well as rocks and debris larger than 1" diameter. Place acceptable backfill material in 6" lifts, compacting each lift. Puddle each trench thoroughly and assure that no sinking occurs.

3.03 INSTALLATION

A. General: Unless otherwise indicated, comply with requirements of the Uniform Plumbing Code. Refer to Section 200 of City of Thornton Standards and Specifications for additional water service specifications and details.

B. Section Valves: Install a jumbo valve box, Carson, arranged for easy adjustment and removal. Brand cover in 1" min. letters 'SV' for section valve and the appropriate station number to controller.
   1. Adjust automatic control valves to provide flow at rated operating pressure required for each sprinkler circuit.
   2. Provide PVC ball valve on upstream side.
   3. Provide one union on upstream side, and one union on downstream side.
   4. Adjust automatic control valves to provide flow rate of rated operating pressure required for each sprinkler zone.
   5. Install one valve per box, arranged for easy adjustment and removal. Allow minimum 12" between valves. Adjust valves to provide flow rate of rated operating pressure required for each lateral.

6. Valve Boxes and Covers: Install one box and cover for each valve installed. Place top 1" above finished grade. Arrange adjacent valve boxes parallel to each other and the same distance apart. Install boxes perpendicular to and on a line with adjacent pavement or walls.

C. Sleeving:
   1. Main and Lateral Line Sleeving:
      a. Install under all paved surfaces as indicated on the drawings.
      b. Minimum depth to top of pipe shall be determined by depth of mainline and lateral lines.
      c. Lay sleeve to drain at minimum grade of 3"/100'.
      d. Ends of Sleeves: Mark all sleeves with a 'X' chiseled in hardscape directly over sleeve location and in manner to ensure easy location in future. Do not allow sleeves to become filled with soil or other undesirable material.

D. Drainage Backfill: Seal with geotextile wrap by taping fabric to inside of valve box and pipe with duct tape.

E. Piping: Lay pipe on solid sub-base, uniformly sloped without humps or depressions.
   1. For Mainline Piping: Slope to drain valve at least 1/2" in 10' run.
   2. Install PVC Pipe: Install in dry weather when temperature is above 40 degrees F. (4 deg. C.) in strict accordance with manufacturer's instructions. Allow joints to cure at least 24 hours at temperature above 40 deg. F. (4 deg. C.) before testing, unless otherwise recommended by manufacturer. Open trenches until testing has been performed. No pipe joints shall be located within sleeve pipes.
   3. Install poured concrete thrust blocks according to city detail with bond breaker between ells, wires, fittings and concrete.

F. Dielectric Protection: Use dielectric fittings at connection where pipes of dissimilar metals are joined. Use dissimilar metals only with Owner's approval.

G. Sprinkler Heads: Flush circuit lines with full head of water and install heads after hydrostatic test is completed.

   Install lawn heads at manufacturer's recommended heights.

   Locate part-circle heads to maintain a minimum distance of 6" from walls and other boundaries, unless otherwise indicated. Allow no backwash or over spray onto walls or fences.

3.04 TESTING

A. General: Notify Owner's representative in writing not less than 16 working hours in advance of when testing will be conducted. Conduct tests in the presence of the Owner's representative.
   1. Before sprinkler heads are set, thoroughly flush the lines to remove all foreign matter.

2. Flush from dead end fittings for a minimum of five minutes under a full head of pressure.

B. Hydrostatic Test: Notify the Owner 72 hours in advance and request observation of hydrostatic test. Prior to test, partially backfill trenches, leaving joints exposed. Test mainline with closed ball valves in place by pressuring to 120 psi for a two-hour period. No more than five (5) psi loss shall occur and no visible leaks shall be detected within a two-hour period in a passing test of mainline & ball valves. Remove and repair piping, connections and valves that leak.

A second pressure test shall be conducted with control valves in place. Pressurize mainline to at least 100 psi, with ball valves open and control valves closed, and visually check for leaks over a two-hour period. Control valve assemblies shall be drip-free at the end of this test.

Flushing: After hydrostatic testing and installation of swing joints for heads, flush lines thoroughly to remove all foreign matter before setting heads. Extend swing joints to levels above grade and flush for a minimum of one minute under full head of pressure.

3.05 ADJUSTING:

A. Upon completion of installation, fine-tune entire system by adjusting patterns and break-up pins, and setting pressure reducing valves at proper and similar pressure to provide optimum and efficient coverage. Flush and adjust all sprinkler heads for optimum performance and to prevent overspray onto walks, roadways and buildings as much as possible. Heads of same type shall be operating at same pressure +/- 10%.

B. If it is determined that irrigation adjustments will provide proper coverage, and improved water distribution as determined by Owner, contractor shall make such adjustments prior to Initial Acceptance, as directed, at no additional cost to Owner. Adjustments may also include changes in nozzle sizes, degrees of arc and control valve throttling.

C. All sprinkler heads shall be set perpendicular to finish grade unless otherwise noted on Construction Plans or directed by Owner.

D. Areas which do not conform to designated operation requirements due to unauthorized changes or poor installation practices shall be immediately corrected at no additional cost to the Owner.

3.06 Walk-Through for Substantial Completion:

A. Arrange for Owner's presence 48 hours in advance of walk-through.

B. Entire system shall be completely installed and operational prior to scheduling of walk-through.

C. Operate each zone in its entirety for Owner at time of walk-through and additionally, open all valve boxes if directed.

D. Generate a list of items to be corrected prior to Final Completion.

E. Furnish all materials and perform all work required to correct all inadequacies of coverage due to deviations from Contract Documents.

F. During walk-through, expose all drip emitters under operations for observation by Owner to demonstrate that they are performing and installed as designed, prior to placing of all mulch material. Schedule separate walk-through if necessary.

G. An irrigation audit of up to fifteen (15) zones, as directed by the city and performed by an Irrigation Association landscape irrigation auditor, is required as part of the Initial Acceptance process.

3.07 Walk-Through for Initial Acceptance:

A. Arrange for Owner's presence 48 hours in advance of walk-through.

B. Show evidence that Owner has received all accessories, charts, record drawings and equipment as required before Initial Acceptance walk-through is scheduled.

C. Operate each zone, in its entirety for Owner at time of walk-through to insure correction of all incomplete items.

D. Items deemed not acceptable by Owner shall be reworked to complete satisfaction of Consultant and Owner.

E. If after request to Owner for walk-through for Initial Acceptance of irrigation system, Owner finds items during walk-through which have not been properly adjusted, reworked, or replaced as indicated on list of incomplete items from previous walk-through, Contractor shall be charged for all subsequent walk-throughs. Funds will be withheld from final payment and/or retainage to Contractor, in amount equal to additional time and expenses required by Owner to conduct and document further walk-throughs as deemed necessary to insure compliance with Contract Documents.

F. Supply Owner with prints of irrigation as-builts prior to scheduling Initial Acceptance walk-through.

3.08 WINTERIZATION AND START UP

A. Installer shall winterize by draining the complete system at the conclusion of the first sprinkling season following Initial Acceptance within 7 days of notification by the Owner. Drain by using compressed air or similar method. Within 7 days of Owner's request, re-open, start-up, test, operate and adjust system accordingly

B. See plan for additional specifications.

END OF SECTION 32 84 00

SECTION 32 92 00 TURFGRASS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Sodding.

2.01 RELATED SECTIONS AND DOCUMENTS

A. Section 32 91 13 – Fine Grading and Soil Preparation.

B. Drawings and General and Special Conditions of the Contract, including Division One and City of Thornton Standards and Specifications for the Design and Construction of Public and Private Improvements and other related specification sections apply to work of this section.

3.01 DEFINITIONS

A. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

B. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 32 91 13 "Soil Preparation" and drawing designations for planting soils.

4.01 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

5.01 INFORMATIONAL SUBMITTALS

A. Certification of grass seed.
   1. Certification of each seed mixture for turfgrass sod.
   2. Load tickets.

B. Product certificates.

C. Seed mixture for each product, including application rates and ratios.

6.01 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf establishment.
   1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
   2. Pesticide Applicator: State licensed, commercial.

7.01 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.

PART 2 - PRODUCTS

1.01 TURFGRASS SOD

A. Turfgrass Sod: Certified, Approved, Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.

B. Sod: Provide strongly rooted sod, not less than two years old, free of weeds and undesirable native grasses and machine cut to pad thickness of 3/4" (+ 1/4"), excluding top growth and thatch. Provide only sod capable of vigorous growth and development when planted (viable, not dormant).
   1. Provide sod of uniform pad sizes with maximum 5% deviation in either length or width. Broken pads or pads with uneven ends will not be acceptable. Sod pads incapable of supporting their own weight when suspended vertically with a firm grasp on upper 10% of pad will be rejected. No netting allowed.
   2. Provide large rolls of sod for areas over 4,000 SF.

C. Turfgrass Species Characteristics:
   1. Provide locally grown sod composed of the following: Four varieties of bluegrass including one Elite drought tolerant, one Elite shade tolerant, one aggressive and one dense, and Perennial Rye Pennfine 10%.

2.01 FERTILIZERS

A. Granular fertilizer 18-46-0 at the rate of 3 lb/1000 SF with the following composition by weight: Nitrogen, eighteen percent (18%) and phosphoric acid (P205), forty-six percent (46%). These elements may be organic, inorganic, or a combination of the two, and shall be measured according to the methods of the Association of Official Chemists.

B.

C. Apply commercial nitrogen fertilizer as specified in Section 32 91 13. Apply after fine grading and prior to compaction.

D. Lightly water to aid the breakdown of fertilizer.

E. Apply fertilizer within 48 hours before laying sod.

3.01 PESTICIDES

A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

PART 3 - EXECUTION

1.01 TURF AREA PREPARATION

A. General: Prepare planting area for soil placement and mix planting soil according to Section 32 91 13 "Soil Preparation."

B. Reduce elevation of planting soil to allow for soil thickness of sod.

C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

D. Before planting, obtain Owner’s acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

2.01 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses.

Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod across slopes exceeding 1:3.
2. Anchor sod on slopes exceeding 3:1 with wood pegs spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

D. Rolling: When soil and sod are moist, roll sod lightly as soon as possible after it is laid. Delay rolling until just before the second watering.

E. Topsoil: Add along exposed edges to match adjacent grade. Feather topsoil out approximately 1 ft. from edge of sod.

F. Drainage: Assure finished areas of sod are such that positive drainage of storm and irrigation water will occur and ponding of water will be minimized.

3.01 TURF MAINTENANCE

A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

B. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Mow to maintain a grass height of 2½-3 inches.

C. Minimum of two (2) weekly mowings.

D. Apply fertilizer after initial mowing (within approximately 20 days after sodding), when grass is dry, using fertilizer that will provide actual nitrogen of at least 1 lb/1000 SF, 20-10-5 plus iron and 8% sulfur fertilizer (50% sulfur coated urea)

Continue fertilizer applications every 30 days thereafter at the rate of ½ lb actual nitrogen per 1000 SF until Initial Acceptance of project--in March, April, May, June, August, September, October and November (no fertilizer in July, December, January, and February).

4.01 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Owner:
   1. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored green typical of the improved turf types installed, viable turf has been established, free of weeds, open joints, bare, dead or discolored spots larger than six (60 inches in any dimension and surface irregularities. No standing water and substantially (less than 5%) free of weeds.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

C. Sod will be considered established when fully rooted and capable of healthy growth with normal 1½" per week post-establishment watering schedules.

END OF SECTION 32 92 00

Page Intentionally Left Blank

SECTION 32 92 19 SEEDING

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Seedbed preparation and weed free approval.

B. Seeding and fertilizing.

C. Hydromulching.

D. Maintaining seeded areas until Initial Acceptance.

1.02 RELATED SECTIONS AND DOCUMENTS

A. Section 32 84 00: Plant Irrigation.

B. Section 32 91 13: Fine Grading and Soil Preparation.

C. Section 32 92 00: Turfgrass.

D. Section 32 93 00: Plants.

E. Drawings and General and Special Conditions of the Contract, including Division One and City of Thornton Standards and Specifications for the Design and Construction of Public and Private Improvements and other related specification sections apply to work of this section.

1.03 REFERENCES

A. Reference Standards: Comply with U.S. Department of Agriculture Rules and Regulations under Federal Seed Act and be equal in quality to standards for Certified Seed.

1.04 SUBMITTALS

A. Quality Control Submittals:
   1. Certificates: State, federal or other inspection certificates shall accompany the invoice for materials showing source or origin. Submit to Owner's Representative prior to acceptance of the material.
   2. Provide seed tags.

B. Contract Closeout Submittals:
   1. Operating and Maintenance Data: At completion of work, include directions for irrigation, aeration, mowing, fertilizing and spraying as required for continuance and proper maintenance through full growing season and dormant period.

1. Contractor to provide all delivery load tickets for seed, fertilizer and mulch prior to acceptance of work under this section.
3. Warranty for Seed Areas: At completion of work, furnish written warranty to Owner based upon requirements as specified. See Section 3.8.

1.05 QUALITY ASSURANCE

A. Planting and seeding shall be done with the approval of the Owner's Representative only when the ground is not frozen, snow covered, or in an otherwise unsuitable condition for planting. Special conditions may exist that warrant a variance in the specified planting dates or conditions. A written request shall be submitted to or originate from the Owner's Representative stating the special conditions and proposed variance.

B. Seeding shall be done within the following dates:
1. Seeding shall not occur until Owner approves amended weed free seeding bed.
2. Seeding date shall include a timeline that incorporates weed emergence and growth to be controlled, including after incorporation of amendment to the bed.
3. For best results for the irrigated warm season seed, provide amended weed free seeding bed for Owner approval by May 1 and seed irrigated warm season grasses by June.

1.06 DELIVERY, STORAGE AND HANDLING

A. Seed: Deliver seed in sealed standard containers stating correct name and composition on the outside of the container. Seed damaged in transit or storage will not be accepted. Retain tickets for submittal to Owner’s Representative.

B. Fertilizer: Deliver inorganic or chemical fertilizer to site in original unopened container bearing manufacturer's guaranteed chemical analysis, name, trade name, trademark and conformance to state law, and bearing name and warranty of producer. Retain tickets for submittal to Owner’s Representative.

C. Material may be inspected upon arrival at project site.

D. Immediately remove the unacceptable material from job site.

1.07 EXISTING CONDITIONS

A. Beginning work means acceptance of existing conditions.

PART 2 - PRODUCTS

2.01 SEED

A. Provide seed mixture at 3 lbs/1000 square feet composed of Native Lawn Mix of 90% Buffalo grass and 10% Blue Grama grass seed by weight available from

Pawnee Buttes Seed Inc. 605 25th Street, Greeley, CO 80632, 1-800-782-5947 or approved equal.

B. All seed shall be furnished in bags or containers clearly labeled to show the name and address of the supplier, the seed name, the lot number, net weight, the percent of weed seed content, and the guaranteed percentage of purity and germination. All brands furnished shall be free from such noxious seeds such as Russian or Canadian Thistle, European Bindweed, Johnson Grass, and Leafy Spurge. The Contractor shall furnish to the Owner's Representative a signed statement certifying that the seed furnished is from a lot that has been tested within six months prior to the date of delivery. Seed which has become wet, moldy, or otherwise damaged in transit or in storage will not be acceptable. Seed shall be certified to be a hardy strain of the following seeds at the indicated rates of pure live seed per acre.

C. Computations for quantity of seed required are based on the percent of purity and percent of germination: Pounds of seed x purity x germination = pounds of pure live seed (PLS).

D. Seed and seed labels shall conform to all current State and Federal regulations and will be subject to the testing provisions of the Association of Official Seed Analysis.

2.02 ACCESSORIES

A. Mulching Material: Bonded fiber matrix.

B. Netting: Soil Saver jute netting or accepted substitute.

C. Staples: Bio-degradable blanket pins.

PART 3 - EXECUTION

3.01 PREPARATION OF FINAL GRADE

A. Protect existing underground improvements from damage.

B. Prepare soil as specified in Section 32 91 13. Owner shall approve seed bed as weed free before seeding operations begin.

C. Moisten prepared seed areas in irrigated areas before planting if soil is dry. Water thoroughly and allow surface moisture to dry before planting seed. Do not create a muddy soil condition.

D. Restore seed areas to specified condition if eroded or otherwise disturbed after fine grading and prior to planting.

3.02 FERTILIZING

A. Apply fertilizer as specified in Section 32 91 13.

B. Do not apply grass seed or fertilizer in same machine at same time.

3.03 SEEDING

A. Drill seeding: Seed to be accomplished using an approved drill seeder.

B. Do not sow immediately following rain, or when ground is too dry, or during windy periods.

C. Apply water with fine spray immediately after each area has been sown.

D. Broadcast Seeding:
   1. Small areas inaccessible to seed drilling equipment to be seeded by broadcast method using a drop or whirly-bird type spreader. Seed shall be broadcast at double the application rates specified above. Apply seed in two equal applications, in perpendicular directions, to assure uniformity.
   2. Lightly rake seeded areas after seed is broadcast. Final raking shall be in a direction perpendicular to the slope of the land.
   3. Seeding will not be permitted when wind velocity is such as to prevent uniform seed distribution. No application shall be undertaken during inclement or the forecast of inclement weather. No application shall take place in the presence of free surface water or when the ground is frozen or otherwise untillable.

3.04 MULCHING

A. No straw products are allowed.

B. Mulch Application: Mulching of seed areas to be accomplished using an approved hydromulcher to apply virgin wood cellulose fiber at rate of 2,000 pounds per acre in a separate applicate after seeding.

C. All areas shall be seeded and hydromulched within thirty (30) days from the date the erosion control permit is issued. Additional time may be granted with written approval from the Erosion Control Inspector.

D. Mulching shall not be done in the presence of free surface water resulting from rains, melting snow, or other causes.

E. Areas not properly mulched, or damaged due to the Contractor's negligence, shall be repaired and remulched in an acceptable manner at the Contractor's expense. Mulch removed by wind prior to acceptance shall be re-established by the contractor at his own expense.

F. The seeded area shall be mulched within 24 hours after seeding. Areas not mulched within 24 hours after seeding must be re-seeded with the specified seed mix at the Contractor's expense.

G. Contractor is to remove all hydromulch from plant materials, fences, paved areas, and buildings as directed by owner.

3.05 EROSION CONTROL

A. If Contractor fails to control such areas and soil erosion subsequently occurs, Contractor shall re-establish finish grade, soil preparation, seed bed, and apply erosion control at his own expense.

3.06 CLEAN UP AND PROTECTION

A. During landscape work, keep pavements clean and work area in an orderly condition. Any damage to other work done by landscape crew is to be reported and repaired immediately.

B. Protect landscape work and materials from damage due to landscape operations, operations by other Contractors and trades and trespassers. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged landscape work as directed.

3.07 INITIAL ACCEPTANCE

A. Seeded areas will be accepted upon the establishment of an even, uniform grass cover of the seed varieties planted. This does not imply that a full sod is necessary. The result is based on a visual evaluation indicating a uniform ground cover of about 90% germination with no bare spots larger than 6" diameter and the area free of weeds and surface irregularities (no rills and gullies), as determined by Owner. Re-seed any areas where seed has not germinated within the total seeding area. Continue this procedure until a successful stand of grass is growing and accepted by the Owner. Contractor to maintain seeded areas until Initial Acceptance.

3.08 FINAL ACCEPTANCE / WARRANTY

A. Warranty for Irrigated Native Seeded Areas: Warrant areas in seed to be in a healthy, vigorous growing condition, and for consistency and completion of coverage at the end of a period of one year from date of Initial Acceptance. Final Acceptance of seeded area shall meet Stormwater Discharge Permit obligations, as applicable. Any areas that do not comply with Final Acceptance criteria shall be reseeded by the Contractor in accordance with these specifications, using specified materials and methods.

END OF SECTION 32 92 19

Page Intentionally Left Blank