PREFACE

PURPOSE OF THIS DOCUMENT

The intent of this document is to disseminate the San Francisco International Airport’s (SFO’s or Airport’s) expectations regarding the information presented to designers, engineers, general contractors and other industry specialists. The material provided in the following sections includes the minimal requirements, general information, design criteria, guide specifications and details for electrical cables, conduits and supports installed at SFO. While this document addresses major areas of concern to SFO, it is not an all-inclusive document.

HOW TO USE THIS DOCUMENT

This document should be used as a resource for the development of project specific design documents including drawings, details and specifications. It is the responsibility of the design, engineering and construction professionals to adhere to all codes and regulations related to the content presented.

SCOPE

This section contains the Standards and Criteria for Electrical Cables, Conduits and Supports. Any questions or concerns regarding the items or equals specified must be submitted to the Standards Committee in writing. All final decisions regarding products shall be made at the Airport’s discretion. If the Engineer of Record presents items that are not specified or named equals, they must be brought to the Standards Committee for evaluation of those products.

QUALITY OF WORKMANSHIP

All electrical work completed at the Airport should be accomplished in a thoughtful, thorough, and organized manner with sustained attention to detail: installation should be precise, and any labeling clear and consistent. In addition, coordination should occur among trades responsible for installation of work occupying the same area so as to facilitate future maintenance of equipment and an efficient use of space.

MC CABLE

Prior to implementing any references to Metal-Clad (MC) Cable detailed in these Standards, the Architect/Engineer must obtain written approval to use MC Cable from his or her SFO Project Manager.

DRAWING REQUIREMENTS

A. All design disciplines including the architectural/engineering sub-consultants and the trade bid package subcontractors shall prepare documents using Revit in the current version utilized by the Airport in compliance with the Airport’s Building Information Modeling (BIM) Requirements as described in Document 00 73 87: BIM Requirements, unless waived by the Chief Development Officer.

B. When Revit models may not be applicable, (for example, tasks with underground infrastructure beyond a building footprint), Civil 3D may be used to model utilities and applicable infrastructure if approved by the Chief Development Officer.

C. Refer to technical specifications for As-Built requirements.

D. Documents and plans submitted to SFO shall be searchable using PDFs with live text. This includes, but is not limited to, text and symbols. The document shall also provide the capability to turn layers on and off. Any
A project using legacy documents which may be composed image files shall be converted to live text via Optical Character Recognition (OCR).

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SECTION 26 05 13 – MEDIUM-VOLTAGE CABLES

PART 1 – GENERAL

1.1 DESCRIPTION

A. Provisions: Applicable provisions of the General Electrical Requirements become a part of this Section as if repeated herein.

B. This Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

C. Contractor shall furnish and install medium voltage cable and/or remove cable for Airports power distribution systems for circuits and locations as shown on the plans.

1.2 REFERENCE STANDARDS

A. Related documents: Drawings, documents, and general provisions of the Contract, including but not limited to General Conditions, apply to this Section.

B. American Society for Testing and Materials (ASTM) Publication:
   1. B3-74 (1980): Specifications for Soft or Annealed Copper Wire

C. Association of Edison Illuminating Companies (AEIC) Publication:
   1. CS8: Specifications for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 through 69kv

D. Institute of Electrical and Electronics Engineers (IEEE) Publication:
   1. 48-1975: Standard Test Procedures and Requirements for High-Voltage Alternating Current Cable Terminations
   2. 386-1985: Separable Insulated Connection Systems for Power Distribution Systems above 600 V

E. National Electrical Manufactures Association (NEMA) Publication

F. Nationally Recognized Testing Laboratory (NRTL)

G. International Electrical Testing Association (NETA) Publication:
   1. ATS-1991: Acceptance Testing Specifications

1.3 SUBMITTALS

A. Catalog Data: Submit manufacturer’s published descriptive literature and specification sheets for the following:
   1. Medium Voltage Cable - All required sizes
2. Cable terminations and splice kits
3. Cable Racking Materials
4. Porcelain Clamps and Associated Hardware
5. Sectionalizing Box and Concrete Pit

B. Submit Cable Manufacturer's AEIC Qualifications Test

C. Product data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.

D. Samples: 16" lengths of each type of cable indicated.

E. Qualification Data: For testing agency.

F. Material Certificates: For each cable and accessory type, signed by manufacturers.

G. Source quality-control test reports.

H. Field quality-control test reports.

1.4 SHIPMENT

A. Test and inspect cables according to ICEA S-97-682 before shipping.

B. Shipment of cable shall be made on reels in such a manner that the cable will be protected from mechanical damage.

C. Each end of the cable shall be hermetically sealed and securely attached to the reel.

D. Minimum diameter of the reel drum shall be 14 times the outside cable diameter.

E. Pulling eyes shall be provided by the manufacturer for each length of cable supplied.

F. Installation of materials and equipment shall be in strict conformity to the recommendations and instructions of the manufacturers of those items.

G. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using test pressure of 5 psig.

1.5 SPECIAL REQUIREMENTS

A. Cables shall be spliced and terminated by an independent sub-contractor, approved by the Airport Planning, Design & Construction Division Electrical Section (PDC), specializing in medium-voltage cable splicing.

B. Certificates

1. Workmen’s Competency: Submit medium voltage cable Splicer/Terminator certification of competency and experience 30 days before splices or terminations are made in medium-voltage cables. Splicer/Terminator experience during the immediate past 3 years shall include performance in splicing and terminating cables of the type and classification being
provided under this contract.

2. Before assigning any cable splicer to work covered by this specification, the Contractor shall provide the contract manager with the names of the cable splicers to be employed, together with satisfactory proof that each splicer has had at least 3 years’ experience in splicing medium-voltage cables, is experienced with the type and rating of cables to be spliced, and is trained and certified by splice material manufacturer. In addition, each cable splicer may be required to make an approved dummy splice in the presence of the contract manager in accordance with cable manufacturer’s instructions, before the splicer is approved to splice cable covered by this specification. All material for dummy splices shall be furnished by the Contractor.

C. Cable shall be installed by contractor with five or more years of demonstrated experience installing medium voltage cable. Submit a list of installations to demonstrate compliance with this requirement.

1.6 IDENTIFICATIONS

A. High-voltage cable identification tags shall be provided for all cables in each manhole, vault, tunnel and all exposed locations.

B. Tags shall be 1/8” thick, 1 ½” x 7”, 3-ply weather-resistant rigid laminated phenolic as manufactured by Hermes Plastics, Inc. or equal. A 1/4” diameter hole shall be drilled ½” from each end of tag to facilitate attachment of tag to cable.

C. Tags shall have red surface with white core bearing the name of the cable as designated. Install an identification tag with cable designation on each conductor with nylon tie-wrap over the cable arc-proof wrapping. Tags shall be installed in each manhole and on all cable of WIRE type splices. Phase letters shall be included in the cable designations.

D. Coordinate with SFO Electrical Shop for color coding for medium-voltage cables.

1.7 TESTING

A. GENERAL. Each test shall be recorded neatly on prepared forms providing complete identification, time, data and signed witness. All test equipment and personnel shall be provided by the Contractor. A qualified testing and inspecting agency should perform field tests, inspections and prepare reports. All test results shall be submitted to the contract manager.

B. CABLES. Cables shall be tested by an approved and third party or independent testing service that is a member company of the International Electrical Testing Association is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction according to NEMA-IPCEA methods at specified stages of installation. The contractor installing and/or splicing the cables shall not be allowed to perform the required testing service. Tests shall be the D.C. voltage test of complete cable with insulation resistance values determined from this test. Contractor shall sign the test reports. Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies shall be present on-site to supervise testing.

1. Individual sections of installed cable shall be tested prior to splicing. Terminations shall be made up and cable ends shall be prepared for permanent splices before test. The contractor shall furnish and install online partial discharge (OLPD) sensors at each circuit while the cables are de-
energized.

2. Completed cable sections, from termination to termination, shall be tested again after all work is done.

3. After termination and splice kits are installed, the following tests shall be conducted in accordance to current NETA acceptance test standards in the presence of the Owner’s representative.
   a. The cables shall be tested using Partial Discharge while cables are de-energized.
   b. The cables shall be tested using Tan-Delta method while cables are de-energized.
   c. The cables shall be tested using Time Domain Reflectometry (TDR) method while cables are de-energized.
   d. The cables shall be tested using the Transient Earth Voltage (TEV) method while cables are de-energized.
   e. The cables shall be tested at 55 KV (DC Test Voltage). Voltage tests shall be applied in 8 KV steps with sufficient time interval before steps for leakage current to stabilize. Record voltage and leakage current at 15, 30, 45 and 60 seconds and one minute intervals thereafter for a total of 15 minutes. At the end of the test period, set the test set voltage control to zero. Allow the residual voltage on the circuit to decay; until the curve flattens out to at least 20% of the test value before applying manual grounds. Record the decay curve and include in the test report. No hi-pot testing of existing cables shall be permitted.

Maximum allowable current registered on the test instrument ammeter (steady State at proper test voltage) shall be determined from the formula shown below. Current readings in excess of those calculated by formula may be cause for rejection of the cable or cable installation.

\[
I = \frac{E}{K} \cdot \frac{L}{\log_{10} \frac{D}{d}}
\]

Where: \( I = \) Current in microamperes (amperes x 10^-6

\( E = \) Test voltage in volts

\( L = \) Length of cable under test in thousands of feet

\( K = \) Constant for grade of insulation per IPCEA NEMA Standards

\( D = \) Diameter over insulation **

\( d = \) Diameter under insulation**

**D and d must be in same units.

4. Prepare cable for test, including disconnecting and sealing ends, and have qualified personnel on hand during test to perform tasks related to test, as directed by the contract manager. Arrangements for test shall be made through the Contract Manager 2 weeks in advance of the proposed day of test.

5. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with requirements.

6. Record and submit all test results to the Airport Project Manager for approval prior to energization. The following information shall be on test reports and includes but not limited to: date, project, circuit identification, cable manufacturer, insulation rating, conductor size, temperature and humidity at time of test, voltage increments, stabilization time, leakage current at final test voltage after 10 minutes, test graphs, megohm meter readings, and names and mode
numbers of instruments used.

7. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.

8. Medium-voltage cables will be considered defective if they do not pass tests and inspections.

9. If any single cable fails testing, all three cables in raceway system shall be replaced and then retest as specified above.

C. FACTORY TESTING. Following approval of the cable submittals, owner’s representatives shall be allowed to witness factory inspections and tests at manufacturer’s cable plant and/or test facility.

1. The cable manufacturer shall demonstrate cable production showing true triple tandem extrusion of Ethylene Propylene Rubber (EPR) insulation in medium voltage cable construction.

2. Manufacturer shall show how they in-house formulate and mix all insulating and semi-conducting compounds used in the cable.

3. Certified evidence shall be submitted that the cable manufacturer has made factory tests on each master length of cable. Copies of the test data shall be submitted to the Engineer. Tests shall include conductor resistance, ionization, and high voltage withstand.

4. The results of these tests shall be submitted prior to shipment of the cable and shall be conducted in accordance with NEMA and AEIC standards.

5. The manufacturer shall notify the owner at least 3 weeks before inspections and tests are scheduled.

PART 2 – MATERIALS

2.1 12 KV POWER CABLES: Power cables shall meet the following:

A. Cables shall meet the latest requirements of UL 1072, AEIC CS6 NEMA WC-8, AEIC CS 8, ICEA S-97-682, ICEA S-93-639 and ICEA S-68-516 for power cables with ethylene propylene rubber insulation.

B. Cables shall be single conductor rated 15 KV ungrounded and UL listed as Type MV-105.

C. Cables shall be capable of operating continuously in both wet and dry locations at a conductor temperature of 90 °C for normal operations, 130 °C under emergency operating conditions and 250 °C under short-circuit conditions. Cable shall be suitable for use in metallic and non-metallic conduits or ducts.

D. Conductor shall be Class B stranded, concentric or compact round, soft or annealed copper per Part 2 of ICEA S68-516.

E. The strand screen shall be extruded black, semi-conducting, thermosetting compound applied over the conductor. The material shall be compatible with the conductor metal, shall be uniformly and firmly bonded to the overlying insulation and be free stripping from the conductor. The contact area between the insulation and strand screen shall not exhibit projections or irregularities which extend from the cylindrical surface of the strand screen by more than 5 mils toward the insulation. Conductor interstices are filled with impermeable compound.

F. The insulation shall be high-quality, heat, moisture, ozone and corona resistant ethylene propylene
The insulation level shall be 133% with nominal thickness of 220 mils. The minimum thickness at any point shall not be less than 90% of the specified thickness. The conductor insulation should have a voltage rating of 15 kV.

G. The insulation shield shall consist of an extruded, semi-conducting, thermosetting compound applied directly over the insulation. The material shall be compatible with the insulation and overlying metallic shield. The insulation shield shall be free stripping from the insulation. The contact area between the insulation and insulation shield shall not exhibit projections or irregularities which extend toward or away from the cylindrical insulation and insulation shield interface by more than 10 mils.

H. The metallic shield shall be 0.005" thick copper tape, helically applied over the insulation shield material with a minimum of 12.5% overlap.

I. The jacket shall consist of tightly extruded polyvinyl chloride (PVC) material meeting the physical and dimensional requirements of ICEA S68-516. The shielding and jacket should be corrugated copper drain wires embedded in extruded, chlorinated polyethylene jacket.

J. The overall jacket shall be surface printed in a contrasting color at two-foot intervals with the following information:
   1. Manufacturer’s Name
   2. Location Code of Plant
   3. Conductor Size
   4. Insulation Type and Thickness
   5. Voltage Rating
   6. UL Designation
   7. Cable length/footage marker

K. The cable manufacturer shall furnish a notarized certificate of compliance to demonstrate that cable furnished is in complete compliance with ICEA S-68-516, Part 3.

L. The cable manufacturer shall supply evidence demonstrating production experience in triple tandem extrusion of EPR insulation in medium voltage cable construction. Manufacturer shall in-house formulate and mix all insulating and semi-conducting compounds used in the cable construction.

M. Cables shall be as manufactured by one of the following:
   1. General Cable.
   2. Okonite Cable.
   3. Prysmian.
   4. No other approved equals known.

N. Obtain cables and accessories through one source from a single manufacturer.

2.2 PORCELAIN CLAMPS

A. If required, cable clamps shall consist of dry process porcelain white glaze with stainless steel clamps. Cable clamp hole size shall suit new cables. Porcelain cable clamps shall be manufactured by Unistrut Corporation or approved equal.
2.3 SPLICES, TERMINATIONS AND ARC-PROOFING

A. Cable splice kits shall contain materials which are completely compatible with the conductor’s insulation, shields, and jackets, and which are approved by the cable manufacturer. Splicing products as recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice with detailed instructions. Use pre-molded, EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable. Splice kits shall be permanent, fully shielded, fully submersible, splice with a current rating equal to that of the cable on which it is installed. Splice kits should comply with IEEE 404. Splice kits shall be Elastimold 25S for straight in-line splices and 655L3 for “T” splices with disconnect-able elbow type construction.

B. 12 KV cable terminations shall consist of preformed stress cones, crimped connectors and grounding device. Termination kits shall be manufactured by one of the following:

1. Elastimold
2. Raychem
3. Cooper Industries
4. Prysmian
5. Or approved equal

C. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield group strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.

D. 12 KV cable wrapping in manholes: Irvington Brand No. 7700, 3” wide arc-proofing tape or equal bishop tape. 3-M Scotch Brand No. 27 tape shall be applied for binding, or equal Permacel tape.

E. Dead break elbows (Separable Connectors): Provide dead break elbows rated 14.4 kv phase to phase, 600 amperes continuous duty as indicated on the Drawings suitable for use on the specified cable and associated equipment. Elbows shall be moisture sealed, suitable for submersible operations and shall consist of a contact probe, a compression type wire connector, and an EPDM rubber insulated housing covered by a semi-conductive shield. Provide dead break elbows with built-in stress relief, stainless steel reinforced pulling eye and capacitive test point with snap cap. Installation shall not require taping, filler compounds or special tools. Elbows shall meet the requirements of IEEE 386 and shall be tested by the manufacturer for corona, high potential, and impulse levels. Elbows shall be as manufactured by:

1. Cooper Industries
2. Elastimold
3. Prysmian
4. Or approved equal

F. Bushing Well Plugs: Provide 15 kv class bushing well plug for all unused bushing wells. Provide well plugs suitable for use with all bushing wells conforming to IEEE 386. Well plugs shall be manufactured by:

1. Cooper Industries
2. Elastimold.
3. Prysmian
4. Or approved equal.

G. Protective Cap: Provide 8.3/14.4 kv rated insulated protective cap with drain wire. Cap shall act to completely water seal energized bushings. Provide a protective cap on all unused bushings.

H. Protective caps shall be as manufactured by:
   1. Cooper Industries
   2. Elastimold.
   3. Prysmian
   4. Or approved equal.

I. Elbow Grounding Kit: Provide 15 kv class, 3-phase elbow grounding kit. Kit shall include carrying case, grounding elbows rated for 10,000 ampere fault close-in at 8.3 kv (phase to ground), protective cap as specified above, 15 kv class test rod, and a portable feed thru rated 8.3/14.4kv. Provide elbow grounding kit as manufactured by:
   1. Cooper Industries
   2. Elastimold.
   3. Prysmian
   4. Or approved equal.

J. Dead break Module: Provide dead break modules for use with separable connectors rated 14.4 kv phase to phase, 600 amperes. All unused bushings shall be covered with an insulating cap as specified above. Modules shall be bracket mounted, have replaceable contacts, stainless steel brackets and hardware, molded-in elbow locking ring, and be suitable for connectors complying with IEE 386. Bracket shall be adjustable to permit changing the pull-off angle. Dead break center modules shall be as manufactured by:
   1. Cooper Industries
   2. Elastimold.
   3. Prysmian
   4. Or approved equal.

K. Tape used for splices and terminations shall be compatible with the insulation and jacket of the cable and shall be of plastic material.

L. Cable Splicing and Terminating Products and Accessories should be manufactured by:
   1. Raychem Corp.; Telephone Energy and Industrial Division; Tyco International Ltd.
   2. Thomas & Betts Corporation
   3. Thomas & Betts Corporation/Elastimold
   4. Prysmian
   5. 3M; Electrical Products Division

2.4 CABLE SUPPORT IN POWER AND TELEPHONE MANHOLES

A. Cable support for underground use shall be PG&E style Kit# 362617 or approved equal.

B. Provide 20” fiberglass rod 1-inch in diameter, support blocks, heavy duty nylon tie (T&B Cat.# TY409 or Panduit PRT5EHQPO), nylon cable block lock (TEKFIT Cat# RD-22 or Tyton SNP-22) for all underground cable supports as shown on the plans.
1. Unapproved nylon lashing ties shall not be used.

2. Maximum 20" cable support rods shall be used. One cable support rod at each end of splice shall be used. Sufficient cable support rods along cable length to relieve strain at splice locations and support cable shall be installed.

3. Cable blocks shall be tightened by hand first and then tightened with channel-lock until immovable.

4. Cable block locks shall not be used to prevent movement of the cable support blocks. Cable block locks are intended to keep cable support blocks from falling off the rod.

5. Only stainless washers and screws shall be used if required.

6. Install minimum of 3 cable support rods per manhole wall racking location, or as shown on the plans.

PART 3 – INSTALLATION

3.1 GENERAL

A. Handling of cables, installing, grounding, spicing and testing shall be accomplished in full compliance with the instructions and recommendations of the cable manufacturer.

3.2 CABLE HANDLING AND INSTALLATION

A. On receipt, cable protective covering shall be inspected for evidence of damage during shipment.

B. Work and storage areas shall be kept clean and dry. Manholes shall be pumped dry and kept dry from the start of duct preparation until all cables are installed and tested. Cables shall be properly supported at all times so they do not lie on the floor or reach within 12" of it.

C. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

D. In manholes, hand holes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.

E. Install terminations at ends of conductors with standard kits.

F. Ground shields of shielded cable at termination and splices. Ground metal bodies of terminators, splices, cable fittings, and hardware.

G. Install cables according to IEEE 576.

H. Identify cables according to Division 26 Section “Identification for Electrical Systems.”

I. Sealing:

1. Each length of cable shall be kept sealed at both ends at all times except when actual splicing or termination is in progress.

2. If cables must be cut, both ends shall immediately be resealed in a manner approved by the cable manufacturer. Seals shall be physically protected.
J. Duct Preparation:

1. Ducts shall be cleaned prior to pulling cables. Immediately before cables are to be pulled, a well fitted swab shall be pulled through the duct in one direction to wipe all foreign matter and moisture from the duct.

2. A mandrel assembly shall be pulled through the duct without forcing. If the mandrel does not easily pass through the duct, the distance pulled to that point be noted and the duct work exposed. Corrections and repairs shall be made to the satisfaction of the contract manager.

3. Existing conduits, into which new cables are to be pulled, shall be cleaned of all debris, even to the extent of “rotary cleaning methods” if required, prior to the passing of a mandrel thru the conduit as described herein before.

K. Cable Pulling:

1. Use only lubricants recommended and approved by the cable manufacturer. Petroleum based products shall not be used as a cable lubricant.

2. Cable reels shall be supported on substantial reel supports located near enough to pull boxes and manholes to permit feeding-in the cable without back-tension or rubbing on the sides of the openings. Reel shall be provided with an approved method for braking.

3. The cable shall be pulled with a power-driven winch, having sufficient power to start and pull the cable without jerking. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable. Pulling speed and cable tension shall not exceed manufacturers’ recommended values.

4. Cable pulling crews shall consist of sufficient manpower to insure the installation of the cable in a safe manner without damage to the cable.

5. Pulling shall be accomplished utilizing a recording dynamometer. Copies of signed dynamometer records shall be submitted to the contract manager, on a daily basis.

6. The pulling cable shall be attached to the conductor of power cable with an approved swivel clevis to prevent twisting cables.

7. The cable must be trained into the duct in a manner that will prevent its dragging on the edge of the duct mouth, or causing backpressure.

8. No pressure or sharp contact shall be applied to the cable jacket which may damage or cause voids to the cable components.

9. Cable sidewall pressures shall not exceed 500 pounds per foot of bend radius. Cable pulling tension shall not exceed 0.008 pounds per cmil of cable area.

10. Cables in vaults, settlement pits, tunnels, and manholes shall be trained onto supporting racks and secured with guides.

11. Cable bending radius shall be per applicable code. Install feeder cables in one continuous length unless splices are favorably reviewed. Minimum radii shall be 12 times the cable O.D.

12. Cable reel shall be set up so that reverse bending is not required. Cable shall be unreeled from the top of the reel. Cables cut in the field shall be immediately sealed with rubber tape and protected with PVC tape. Cables for splicing shall be overlapped by a minimum of two feet.
Cables shall be looped around the manhole circumference before exiting again.

13. Cable pulling by means of a vehicle is not allowed. The contractor shall have all the necessary cable installation equipment.

14. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.

15. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.

L. Cable Splicing

1. Splices shall be carefully made-up in strict conformance with the manufacturer’s instructions.

2. Once splice or termination work has been started, work shall continue in one continuous work period until completed.

3. Under no conditions shall termination or splice work be subjected to moisture. Tents shall be available at the work site to protect the area from rain. Pumps shall be available for keeping manholes dry. Blowers shall be provided to force fresh air into manholes where free air circulation is obstructed. Unused ducts shall be kept plugged. A manhole ring shall be used as a continuous curb, 6” high to keep surface water away during all cable work.

4. Locate splices midway between cable racks and support on cable arms at enclosing conduit heights.

5. After preparation of cable ends the splice shall be assembled with the required basic components, in the desired configuration, using tools recommended by the manufacturer.

6. Splices shall be installed in such a manner which will allow removal without disturbing other splices and cables.

7. Provide heat shrinkable water tight elbow seal adapters (ESA) at each 3-way splice.

M. Cable Termination

1. Clean mating surfaces by using stainless steel wire brush.

2. Use crimping tools, dies and technique as recommended by manufacturer.

3. Protect insulation from heat when soldering, brazing, or welding. Make insulation cutback longer and wrap insulation with tape. Use only rosin flux when soldering copper electrical connections.

N. Cable Grounding

1. Shields at splices and terminations, shall be solidly grounded.

2. Grounding systems shall be complete including all necessary cables and grounding copper to provide a permanent and effective ground.

3. Connections of grounding wires shall be made only to cleaned, scale and corrosion free metal surfaces.

4. Grounding connections shall be made utilizing installation tools and recommendations of the grounding equipment material manufacturer.
O. CABLE ARC PROOFING

1. All power cables in vaults, settlement pits, tunnels, pull boxes and manholes shall be wrapped with arc proofing tape.

2. Tape shall be wrapped in either 2 layers butt-taped with second layer covering joints in the first layer or one layer half taped.

3. Wrapping shall extend the full length of the cable from duct entrance to duct entrance, except where splices are installed. Splices shall be left uncovered and wrapping shall stop at grounding device.

P. CABLE REMOVAL

1. Cables to be removed shall be tested first as dead circuit and positively identified prior to disconnecting. It shall be safely disconnected and pulled out without disturbing any circuit considered live or operational within the same raceway, manhole or other electrical equipment.

2. All empty conduit entrances shall be plugged with Airport approved material.

3. Upon removal of the cable, contractor shall install cables in a reel or cut cables to length and deposit at the bin or collection containers provided on-site by others.

END OF SECTION 26 05 13
SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 – GENERAL

1.1 DESCRIPTION

A. Provisions: Applicable provisions of Section 26 become a part of this Section as if repeated herein.

B. This section includes building wires and cables rated 600 V and less, connectors, splices and terminations rated 600 V and less.

C. Related Work Described Elsewhere:
   1. Drawings, documents, and general provisions of the Contract, including but not limited to General Conditions, apply to this Section.
   2. General Electrical Requirements
   3. Medium Voltage Cables: Section 26 05 13
   4. Control-Voltage Electrical Power Cables: Section 26 05 23
   5. Conduit, Raceway and Fittings: Section 26 05 34

1.2 REFERENCE STANDARDS

A. American National Standards Institute (ANSI) Publications:
   1. B3-74 (1980): Specification for soft or Annealed Copper Wire
   2. B-8-77: Specification for Concentric Lay Stranded Copper Conductors, Hard, Medium- Hard, or Soft

B. Insulated Cable Engineers Association (ICEA):
   1. S-66-524: Cross-Linked Thermosetting Polyethylene Insulated Wire and Cable

C. Underwriters Laboratories (UL) Standards:
   1. 44-1986: Rubber Insulated Wire and Cable
   2. 62-1987: Flexible Cords and Fixture Wire
   4. 510-1986: Insulating Tape
   5. 719-1985: Non-Metallic Sheath Cable
   6. 1063-1986: Stranded Conductors for Machine Tool Wire
D. National Fire Protection Association (NFPA) 270
E. Nationally Recognized Testing Laboratory (NRTL)
F. National Electrical Manufacturers Association (NEMA)
G. National Electrical Code (NEC)

1.3 SUBMITTALS
A. Catalog & Product Data: Provide Manufacturers published descriptive literature properly marked for each type of product indicated.
B. Single Submittal: One (1) hard copy and one (1) electronic copy is required for all products covered by this Section.
C. Qualification Data: For testing agency.
D. Field quality-control test reports.

1.4 LOCATIONS
A. Refer to General Electrical Requirements, for definitions of types of locations.

PART 2 – PRODUCTS

2.1 GENERAL
A. All conductors shall be copper. Wire or cable not specially shown on the Drawings or specified, but required, shall be of the type and size required for the application and in conformance with the applicable code. All insulated conductors shall be identified with printing colored to contrast with the insulation color. All copper conductors must comply with NEMA WC 70.

1. Conductor insulation must comply with NEMA WC 70 for types THHN-2, THWN-2, and SO.
2. Multi-conductor cable must comply with NEMA WC 70 for metal-clad cable, Type MC and with ground wire.
B. Power and Control Conductors, 2,000 Volts and Below:

1. 600 volts copper wires shall be UL and NEC approved, Types TW, THW, XHHW or dual rated THHN-THWN, 90 ºC rated only.
2. Cord service, of adequate length and with grounding type plug attached, shall be rated in amperes suitable for the temporary service being connected as shown on the contract drawings.
3. MC Cable for branch circuits feeding Airport-recessed lighting and receptacle loads is permitted in concealed spaces only.

C. Material Applications:

1. Feeders: Copper. Stranded.
2. Branch Circuits: Copper. Stranded or solid.
D. **Available Manufacturers Conductors and Cables: Subject to compliance with requirements:**

2. General Cable Corporation.
5. Or approved equal.

2.2 **SPICES AND TERMINATIONS OF CONDUCTORS**

A. **Description:** Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

B. **Splices:**

1. Wire nuts shall be twist-on type insulated connectors utilizing an outer insulating cover and a means for connecting and holding the conductors firmly. They shall be UL listed and suitable for connecting two to four solid copper conductors of #14 or #12 AWG size or two or three #10 AWG solid copper conductors.

2. Crimp type connectors shall be sleeve type, suitable for the size and material of the wires and the number of wires to be spliced and for use with either solid or stranded conductors. They shall be UL listed.

3. Bolted pressure connectors shall be suitable for the size and material of the conductors to be spliced. They shall be UL listed and of the split bolt or bolted split sleeve type in which the bolt or set screw does not bear directly on the conductor.

4. Epoxy splice kits shall include epoxy resin, hardener, and mold, and shall be suitable for use in wet locations.

C. **Low Voltage Terminations:**

1. Crimp type terminals shall be UL listed, self-insulating sleeve type, with fork type tongue, suitable for the size and material of the wire to be terminated, and for use with either solid or stranded conductors.

2. Terminal lugs shall be UL listed and of the split bolt or bolted split sleeve type in which the bolt or set screw does not bear directly on the conductor. Tongues shall have NEMA standard drilling.

D. **Tape used for splices and terminations shall be compatible with the insulation and jacket of the cable and shall be of plastic material. Tape shall conform to UL 510.**

E. **Wire markers shall be vinyl cloth adhesive type, or plastic sleeve type. Wire numbers shall be permanently imprinted on the markers.**

F. **Available Manufacturers: Subject to compliance with requirements:**

1. AFC Cable Systems, Inc.
PART 3 – EXECUTION

3.1 CONDUCTOR INSTALLATION

A. Provide the following types and sizes of conductors for the uses indicated for 600 volts or less:

1. Solid Copper, Sizes #12 14 AWG and smaller: As shown on the Drawings for circuits for receptacles, switches and light fixtures with screw-type terminals.

2. Stranded Copper, sizes #10 12 AWG and larger: As shown on the drawings for motors and other power circuits.

3. Fixture Wire: For connections to all fixtures in which the temperature may exceed the rating of branch circuit conductors.

B. Color Coding: Provide color coding for all circuit conductors. Insulation color shall be white for 120V and grey for 277V neutrals, and green for grounding conductors. An isolated ground conductor shall be identified with an orange tracer in the green body. Ungrounded conductor colors shall be as follows:

1. 120/208 Volt, 3 Phase: (A) black, (B) red, (C) blue

2. 277/480 Volt, 3 Phase: (A) brown, (B) orange, (C) yellow

3. 120/240 Volt, 1 Phase: Red and Black

C. Exercise care in pulling wires and cables into conduit or wire ways so as to avoid kinking, putting undue stress on the cables or otherwise abrading them. No grease will be permitted in pulling cables. Only soapstone, talc, or UL listed pulling compound will be permitted. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer’s recommended maximum pulling tensions and sidewall pressure values.

D. The raceway construction shall be complete and protected from the weather before cable is pulled into it. Swab conduits before installing cables and exercise care in pulling, to avoid damage to conductors.

E. Cable bending radius shall be per applicable code. Install feeder cables in one continuous length unless splices are favorably reviewed.

F. Provide an equipment grounding conductor, whether or not it is shown on the Drawings, in any conduit or any raceway. For flexible conduit, an external bonding jumper is an acceptable alternative.

G. In panels, bundle incoming wire and cables, No. 6 AWG and smaller, lace at intervals not greater than 6", neatly spread into trees and connect to their respective terminals. Allow sufficient slack in cables for alterations in terminal connections. Perform lacing with plastic cable ties or linen lacing twine. Where plastic panel wiring duct is provided for cable runs, lacing is not necessary when the...
cable is properly installed in the duct.

H. For cables crossing hinges, utilize extra flexible stranded wire, make up into groups not exceeding 12, and arrange so that they will be protected from chafing when the hinged member is moved.

I. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

J. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

K. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

L. Support cables according to Section 26 05 29 – Hangers and Supports for Electrical Systems.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-2, THWN-2, single conductors in raceway.

B. Exposed Feeders: Type THHN-2, THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-2, THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-2, THWN-2, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-2, THWN-2, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2, THWN-2, single conductors in raceway. Type MC is permitted in concealed spaces only.

G. Branch Circuits Concealed in Concrete, below Slabs-On-Grade, and Underground: Type THHN-2, THWN-2, single conductors in raceway.

H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, and strain relief device at terminations to suit application.

I. Branch Circuits in Cable Tray: Type THHN-2-THWN-2, single conductors in raceway.

J. Class 1 Control Circuits: Type THHN-2, THWN-2, in raceway.

K. Class 2 Control Circuits: Type THHN-2, THWN-2, in raceway.

3.3 CONDUCTOR SPLICES AND TERMINATIONS

A. Splices: Install all conductors without splices unless necessary for installation, as determined by the Engineer. Splices, when permitted, and terminations shall be in accordance with the splice or termination kit manufacturer’s instructions. Splice or terminate wire and cable as follows:
1. Watertight Splices: Splices in concrete hand holes and manholes, for any type of cable or wire, shall be watertight. Make splices in low voltage cables using epoxy resin splicing kits rated for application up to 600 volts.

B. Terminations:
1. Terminate stranded wire using spade terminals, or equal, where not terminated in a box lug type terminal.

C. Connections
1. 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.
2. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   a. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
3. Wiring at Outlets: Install conductor at each outlet, with at least 6” of slack.

3.4 CONDUCTOR IDENTIFICATION
A. Low voltage cable identification tags shall be provided for all cables in each manhole, vault, tunnel, pull box and all exposed locations.
B. Tags shall be 1/8” thick, 1 ½” x 7”, 3-ply weather resistant rigid laminated phenolic as manufactured by Hermes Plastics, Inc. or equal. A 1/4” diameter hole shall be drilled ½” from each end of tag to facilitate attachment of tag to cable.
C. Tags shall have red surface with white core bearing the name of the cable as designated.
D. Install an identification tag with cable designation on each conductor with nylon tie-wrap over the cable arc-proof wrapping. Tags shall be installed in each manhole and on all cable of WIRE type splices. Phase letters shall be included in the cable designations.

3.5 FIRESTOPPING
A. Apply fire stopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to “Penetration Fire stopping Systems” requirements.

3.6 FIELD TESTS
A. Testing Agency Qualifications:
1. Engage an independent agency, with the experience and capability to conduct the testing indicated, inspections, and prepare test reports, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 FR 1910.7 and that is acceptable to authorities having jurisdiction.
2. Testing Agency’s Field Supervisor: Person currently certified by the International Electrical
Testing Association or the National Institute for Certification

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.
   1. Comply with NFPA 70.

C. Insulation Resistance Tests: Perform insulation resistance tests on circuits to be energized with a line-to-neutral voltage of 480 volts or more. Make these tests after all equipment has been connected, except that equipment which may be damaged by the test voltage shall not be connected. For 480 volt wiring, test the insulation with a 1000 vdc insulation resistance tester. The insulation resistance shall be 20 megohms or more. Submit results for review.

D. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

E. Phase Rotation: The phase rotation of all circuits shall be clockwise in sequence. The Contractor shall verify that each three-phase service, feeder and branch circuits meet this requirement. A record shall be kept for each circuit tested and, on completion, given to the Engineer for review.

F. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger.
   1. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial actions.

G. Test Reports: Prepare a written report to record the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

H. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 19
SECTION 26 05 23 – CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, documents, and general provisions of the Contract, including but not limited to General Conditions and Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. UTP cabling.
   2. RS-232 cabling.
   3. RS-485 cabling.
   4. Low-voltage control cabling.
   5. Control-circuit conductors.
   6. Identification products.

1.3 REFERENCES

A. Comply with the latest versions of the following Standards
   1. National Fire Protection Association (NFPA)
   2. Nationally Recognized Testing Laboratory (NRTL)
   3. National Electrical Code (NEC)
   4. ETL Markings
   5. Underwriters Laboratories (UL)
   6. National Electrical Contractors Association (NECA)
   7. Telecommunications Industry Association (TIA) Standards

1.4 DEFINITIONS

A. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.

B. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel section.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
F. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50V or for remote-control and signaling power-limited circuits.

G. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

H. RCDD: Registered Communications Distribution Designer.

I. UTP: Unshielded twisted pair.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

C. Source quality-control reports.

D. Field quality-control reports.

E. Maintenance Data: For wire and cable to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of an NRTL.
   1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
   1. Flame Travel Distance: 60” or less.
   2. Peak Optical Smoke Density: ½ or less.
   3. Average Optical Smoke Density: 0.15 or less.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.
   1. Test each pair of UTP cable for open and short circuits.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install UTP and optical fiber cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the
remainder of the construction period.

PART 2 – PRODUCTS

2.1 UTP CABLE

A. Manufacturers: Subject to compliance with requirements:
   1. Belden CDT Inc.; Electronics Division.
   2. Berk-Tek; a Nexans company.
   3. CommScope, Inc.
   4. Draka USA.
   5. Genesis Cable Products; Honeywell International, Inc.
   6. KRONE Incorporated.
   7. Mohawk; a division of Belden CDT.
   8. Nordex/CDT; a subsidiary of Cable Design Technologies.
   9. Superior Essex Inc.
   10. SYSTIMAX Solutions; a CommScope, Inc. brand.
   11. 3M.
   12. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
   13. Or approved equal.

B. Description: 100-ohm, four-pair UTP.
   1. Comply with ICEA S-90-661 for mechanical properties.
   2. Comply with TIA/EIA-568-B.1 for performance specifications.
   4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
      a. Communications, General Purpose: Type CM or Type CMG.
      b. Communications, Plenum Rated: Type CMP/MPP, complying with NFPA 262.
      c. Multipurpose: Type MP or Type MPG.
      d. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.

2.2 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Dynacom Corporation.
   3. Hubbell Premise Wiring.
   4. KRONE Incorporated.
   5. Leviton Voice & Data Division.
6. Molex Premise Networks; a division of Molex, Inc.
7. Nordex/CDT; a subsidiary of Cable Design Technologies.
8. Panduit Corp.
10. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
11. Or approved equal.

B. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.

C. Connecting Blocks: 110 style for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare; integral with connector bodies, including plugs and jacks where indicated.

2.3 RS-232 CABLE

A. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, two pairs, No. 22 AWG, stranded (7 x 30) tinned-copper conductors.
2. Plastic insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7 x 32) tinned-copper drain wire.

2.4 RS-485 CABLE

A. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, two pairs, No. 22 AWG, stranded (7 x 30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: Comply with UL 1685.

2.5 LOW-VOLTAGE CONTROL CABLE

A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.

2.6 CONTROL-CIRCUIT CONDUCTORS

A. Class 1 Control Circuits: Stranded copper, Type THHN-2, THWN-2, in raceway, complying with UL 83.
B. Class 2 Control Circuits: Stranded copper, Type THHN-2, THWN-2, in raceway, complying with UL 83.
C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF, complying with UL 83.

2.7 IDENTIFICATION PRODUCTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Brady Corporation.
   2. HellermannTyton.
   3. Kroy LLC.
   4. Panduit Corp.
   5. Or approved equal.
B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
C. Comply with requirements in Section 26 05 53 “Identification for Electrical Systems.”

2.8 SOURCE QUALITY CONTROL

A. Factory test UTP cables according to TIA/EIA-568-C.2.
B. Cable will be considered defective if it does not pass tests and inspections.
C. Prepare test and inspection reports.

PART 3 – EXECUTION

3.1 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.
B. General Requirements for Cabling:
C. Cable will be considered defective if it does not pass tests and inspections.
   1. Comply with BICSI ITSIMM, Ch. 5, “Copper Structured Cabling Systems.”
   2. Terminate all conductors; no cable shall contain un-terminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
   3. Cables may not be spliced. Secure and support cables at intervals not exceeding 30” and not more than 6” from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer’s limitations on bending radii, but not less than radii specified in BICSI ITSIM, “Cabling Termination Practices” Chapter. Install lacing bars and distribution spools.
   5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
   6. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
   7. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, “Pulling Cable.” Monitor cable pull tensions.

D. UTP Cable Installation:
   2. Install 110-style IDC termination hardware unless otherwise indicated.
   3. Do not untwist UTP cables more than ½” from the point of termination to maintain cable geometry.

E. Installation of Control-Circuit Conductors:
   1. Install wiring in raceways. Comply with requirements specified in Section 26 05 33 “Raceway and Boxes for Electrical Systems.”

F. Open-Cable Installation:
   1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
   2. Suspend copper cable not in a wire way or pathway a minimum of 8” above ceilings by cable supports not more than 60” apart.
   3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

G. Separation from EMI Sources:
   1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
   2. Separation between open communications cables and unshielded power conductors and electrical equipment shall be as follows:
a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5”.
b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12”.
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24”.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2 ½”
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6”
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12”

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3”
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6”

5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or Equivalent HP and Larger: A minimum of 48”

6. Separation between Cables and Fluorescent Fixtures: A minimum of 5”

3.2 CONTROL-CIRCUIT CONDUCTORS

   A. Minimum Conductor Sizes:
      1. Class 1 remote-control and signal circuits, No 14 AWG.
      2. Class 2 low-energy, remote-control, and signal circuits, No. 16 AWG.
      3. Class 3 low-energy, remote-control, alarm, and signal circuits, No 12 AWG.

3.3 FIRESTOPPING

   A. Comply with requirements in “Fire stopping Systems” requirements.

3.4 GROUNDING

   A. For low-voltage wiring and cabling, comply with requirements in Section 26 05 26 “Grounding and Bonding for Electrical Systems.”

3.5 IDENTIFICATION

   A. Identify system components, wiring, and cabling according to TIA/EIA-606-A. Comply with requirements for identification specified in Section 26 05 53 “Identification for Electrical Systems.”
   B. Furnish and install Arc flash labels on all electrical equipment in accordance with the NEC.
3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections
   1. Visually inspect UTP and optical fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
   2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   3. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross connection.
      a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 26 05 23
SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes methods and materials for grounding systems and equipment, including:
   1. Active electrodes.
   2. Wire.
   3. Grounding well components.
   4. Mechanical connectors.
   5. Exothermic connections.

B. Related Sections:
   2. Access Flooring: Grounding systems for access flooring.
   3. Drawings, documents, and general provisions of the Contract, including but not limited to General Conditions, apply to this Section.

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers:

B. International Electrical Testing Association:

C. National Electrical Contractors Association:
   1. NECA 1 – Standard for Good Workmanship in Electrical Construction.

D. National Electrical Manufacturers Association (NEMA):
   1. GR 1 – Ground Rod Electrodes and Grounding Rod Electrode Coupling.

E. National Fire Protection Association:
   1. NFPA 70 – National Electrical Code. (NEC)
F. NFPA 780 – Standard for the Installation of Lightning Protection Systems. Underwriters Laboratories:
   1. UL 467 – Grounding and Bonding Equipment.

1.3 SYSTEM DESCRIPTION

A. Grounding systems use the following elements as grounding electrodes:
   1. Metal building frame.
   2. Concrete-encased electrode.
   4. Rod electrode.
   5. Plate electrode.

1.4 DESIGN REQUIREMENTS

A. Construct and test grounding systems for access flooring systems on conductive floors accordance
   with IEEE 1100.

1.5 PERFORMANCE REQUIREMENTS

A. Grounding System Resistance: Less than 5 ohms.

1.6 SUBMITTALS

A. As per Submittal requirements.
B. Product Data: Submit data on grounding electrodes and connections.
C. Test Reports: Indicate overall resistance to ground.
D. Qualification Data: For testing agency and testing agency’s field supervisor.
E. Field quality-control test reports.
F. Manufacturer’s Installation Instructions: Submit for active electrodes.
G. Manufacturer’s Certificate: Certify Products meet or exceed specified requirements.
H. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding
   features specified in Part 3 “Field Quality Control” Article, including the following:
   1. Test wells.
   2. Ground rods.
   3. Grounding arrangements and connections for separately derived systems.
I. Operations and maintenance Data: For grounding to include the following in emergency,
   operation, and maintenance manuals:
1. Instructions for periodic testing and inspection of grounding features at test wells and grounding connections for separately derived systems based on NETA MTS.
   a. Tests shall be determined if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
   b. Include recommended testing intervals.

1.7 CLOSEOUT SUBMITTALS
   A. As per Contract Closeout and Project Record Documents requirements.

1.8 QUALITY ASSURANCE
   A. Provide grounding materials conforming to requirements of NEC, IEEE 142, and UL label. Comply with UL 467 for grounding and bonding materials and equipment.
   B. Perform Work in accordance with NEC and/or SFO ABR.
   C. Maintain two copies of each document on site.
   D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.9 QUALIFICATIONS
   A. The Manufacturer and Installer must have minimum 5 years’ documented experience in providing services as required by this section.
   B. Testing Agency Qualifications: Member Company of NETA or an NRTL.
      1. Testing Agency’s Field Supervisor: Certified by NETA to supervise on-site testing.

1.10 PRE-INSTALLATION MEETINGS
   A. As per requirements of Project Meetings.

1.11 DELIVERY, STORAGE, AND HANDLING
   A. As per requirements of Material and Equipment.
   B. Accept materials on site in original factory packaging, labeled with manufacturer’s identification.
   C. Protect from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original packaging.
   D. Do not deliver items to project before time of installation. Limit shipment of bulk and multiple-use materials to quantities needed for immediate installation.

1.12 COORDINATION
   A. As per requirements of Work Coordination.
B. Complete grounding and bonding of building reinforcing steel prior concrete placement.

PART 2 – PRODUCTS

NOTE: All types/classifications of equipment shall be identified to have grounding with specific types of grounding conductors and attachments. Table of relevant equipment (grouped by type) shall be added with the relevant conductor and attachments listed.

2.1 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, sectional type; 3/4” by 120”.

B. Manufacturers: Subject to compliance with requirements, provide grounding products of one the following:
   1. Apache Grounding/Erico Inc.
   2. Copperweld, Inc.
   3. Erico, Inc.
   4. O-Z Gedney Co.
   5. Thomas & Betts, Electrical Corp.
   6. Or approved equal.

C. Furnish materials in accordance with NEC and/or SFO ABR.

2.2 WIRE

A. Material: Stranded copper.

B. Foundation Electrodes: As shown on drawings.

C. Grounding Electrode Conductor: Copper conductor bare or insulated.

D. Bonding Conductor: Copper conductor bare or insulated.

2.3 MECHANICAL CONNECTORS

Note the corresponding document lists simply “connectors” but specifies copper connectors

A. Manufacturers:
   1. Apache Grounding/Erico Inc.
   2. Copperweld, Inc.
   3. Erico, Inc.
   4. ILSCO Corporation.
   5. O-Z Gedney Co.
   6. Thomas & Betts, Electrical
   7. Or approved equal.

B. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
C. Furnish materials in accordance with NEC.

D. Description: Bronze connectors, suitable for grounding and bonding applications, in configurations required for particular installation.
   1. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
   2. Pipe Connectors: Clamp type, sized for pipe.
   3. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
   4. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solder less compression type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.4 EXOTHERMIC CONNECTIONS

A. Manufacturers:
   1. Apache Grounding/Erico Inc.
   2. Cadweld, Erico, Inc.
   3. Copperweld, Inc.
   4. ILSCO Corporation
   5. O-Z Gedney Co.
   6. Thomas & Betts, Electrical
   7. Or approved equal.

B. Furnish materials in accordance with NEC.

C. Product Description: Exothermic materials, accessories, and tools for preparing and making permanent field connections between grounding system components.

2.5 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
   2. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4” in diameter.
   3. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
   4. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8” wide and 1/16” thick.
   5. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8” wide and 1/16” thick.

C. Grounding Bus: Rectangular bars of annealed copper, Size as indicated on plans; with insulators.

PART 3 – EXECUTION

3.1 EXAMINATION
A. As per Job Site Administration requirements.

B. Verify final backfill and compaction has been completed before driving rod electrodes.

3.2 PREPARATION

A. Remove paint, rust, mill oils, and surface contaminants at connection points.

3.3 EXISTING WORK

For Designer: Add in methods for testing tie-ins to existing work where tie-ins are necessary or optional.

A. Modify existing grounding system to maintain continuity to accommodate renovations.

B. Extend existing grounding system using materials and methods compatible with existing electrical installations.

C. Requirements for testing existing grounds where tie-in to existing grounding systems are required and/or optional shall be identified.

3.4 INSTALLATION

A. Conductors: Stranded copper unless otherwise indicated.

B. Install in accordance with IEEE.

C. Install additional rod electrodes to achieve specified resistance to ground.

D. Install grounding and bonding conductors concealed from view.

E. Install grounding well pipe with cover at each rod location. Install well covers top flush with finished grade.

F. Install grounding electrode conductor and connect to reinforcing steel in foundation footing as indicated on Drawings if applicable. Electrically bond steel together.

G. Bond together metal siding not attached to grounded structure; bond to ground.

H. Install copper bonding conductor per NEC.

I. Connect to site grounding system.

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

K. Ground Rods: Drive rods until tops are 2” below finished floor or final grade, unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

L. Test Wells: Ground rod driven through drilled hole in bottom of hand hole. Hand holes are specified in Section 26 05 43 “Underground Ducts and Raceways for Electrical Systems,” and shall be at least 12” deep, with cover.

M. Test Wells: Install at least one test well for each service, unless otherwise indicated.

N. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

O. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.

3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

4. Provide separate aircraft static grounding receptacle closest to aircraft grounding connection points. Ground resistance shall be 25 ohms or less. Stencil on the surface the install date and resistance achieved.

P. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

Q. Bonding Interior Metal Ducts: Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

R. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

S. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
1. If concrete foundation is less than 20’ long, coil excess conductor within base of foundation.

2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

T. PBB ground support electrical equipment shall have grounding bonded to building ground.

3.5 GENERAL GROUNDING

A. Install continuous grounding using underground cold water system and building steel as grounding electrode. Where water piping is not available, install artificial station ground by means of driven rods or buried electrodes.

B. Permanently ground entire light and power system in accordance with NEC, including service equipment, distribution panels, lighting panel boards, switch and starter enclosures, motor frames, grounding type receptacles, and other exposed non-current carrying metal parts of electrical equipment.

C. Install branch circuits feeding isolated ground receptacles with separate insulated grounding conductor, connected only at isolated ground receptacle, ground terminals, and at ground bus of serving panel.

D. Accomplish grounding of electrical system by using insulated grounding conductor installed with feeders and branch circuit conductors in conduits. Size grounding conductors in accordance with NEC. Install from grounding bus of serving panel to ground bus of served panel, grounding screw of receptacles, lighting fixture housing, light switch outlet boxes or metal enclosures of service equipment. Ground conduits by means of grounding bushings on terminations at panel boards with installed 12AWG conductor to grounding bus per NEC.

E. Grounding electrical system using continuous metal raceway system enclosing circuit conductors in accordance with NEC.

F. Permanently attach equipment and grounding conductors prior to energizing equipment.

G. Isolated Grounding Conductors:
   1. Install conductor for circuits supplying personal computers in accordance with IEEE 1100.
   2. Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

H. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Install bus horizontally on insulated spacers 1”, minimum, from wall and 6” above finished floor, unless otherwise indicated.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.

I. Conductor Terminations and Connections:
1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.

### 3.6 UNDERGROUND GROUNDING CONDUCTORS AND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEE C2 grounding requirements.

B. Install bare, tinned-copper conductor, No. 4/0 AWG minimum for 12 kV systems. Size grounding conductor per NEC for voltages below 12 kV.

C. Bury at least 24" below grade.

D. Duct bank grounding conductor shall be encased in concrete along with the duct banks.

E. Grounding Manholes and Hand holes: Install a driven ground rod through manhole or hand hole floor, close to wall, and set rod depth so 4" will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 4/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2" above to 6" below concrete. Seal floor opening with waterproof, non-shrink grout. Use 3/4” x 10’ copper ground rod.

F. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or hand hole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductor’s level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

G. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6’ from the foundation.

### 3.7 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Terminate each end on suitable lug, bus, or bushing.

C. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Three-phase motor and appliance branch circuits.
3. Flexible raceway runs.


D. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

E. Water Heater: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

F. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panel board grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

G. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panel board grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

H. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a ¼” x 2” x 12” grounding bus.

2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.8 FIELD QUALITY CONTROL

A. As per Quality Control and Contract Closeout requirements.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Perform the following tests and inspections and prepare test reports:

1. Grounding and Bonding
   a. Perform inspections and tests listed in NETA ATS, Section 7.13.

2. Perform ground resistance testing in accordance with IEEE 142.

3. Perform leakage current tests in accordance with NFPA 99.

4. Perform continuity testing in accordance with IEEE 142.

5. After installing grounding system but before permanent electrical circuits have been energized,
test for compliance with requirements.

6. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
   a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
   b. Perform tests by fall-of-potential method according to IEEE 81.

D. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

E. When improper grounding is found on any receptacles, correct in accordance with IEEE 142.

F. The neutrals of transformers, raceways, non-current carrying metal parts of fixed equipment and other equipment required to be bonded or grounded shall comply with NEC Section 250.

G. Install clamp-on connectors only on thoroughly cleaned metal contact surfaces, to ensure electrical conductivity and circuit integrity.

H. Coordinate with other work as necessary to interface installation of electrical grounding system.

I. Flexible metallic conduit raceway to fixed motors shall enclose a code sized grounding conductor in each case where the circuit conductors in the flexible conduit are larger than #12 AWG.

J. Provide code sized equipment ground wires in all conduit runs and bond all conduits and equipment ground at all location to building ground bus to obtain minimum impedance.

K. Report measured ground resistance that exceed the following values:
   1. Power and Lighting Equipment or System with Capacity 500 kVA and less: 10 ohms.
   2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
   3. Power Distribution Units or Panel Boards Serving Electronic Equipment: 3 ohm(s).
   5. Manhole Grounds: 10 ohms.

L. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer or Airport Project Manager promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26
SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Conduit supports.
   2. Formed steel channel.
   4. Sleeves.
   5. Mechanical sleeve seals.
   6. Fire stopping relating to electrical work.
   7. Fire stopping accessories.
   8. Equipment bases and supports
   10. Hangers and supports for electrical equipment and systems.

1.2 REFERENCES

A. Comply with the latest versions of the following references:
   1. American Society for Testing and Materials:
   3. Metal Framing Manufacturers Association (MFMA) 4 - Metal Framing Standards Publication.
5. Underwriters Laboratories Inc.:
   a. UL 58 - Strut-Type Channel Raceways and Fittings
   d. UL 1479 - Standards for Fire Tests of Through-Penetration Fire stops.
   e. UL - Fire Resistance Directory.
7. California Code of Regulations (CCR), Title 24, Building Standards.
   a. Part 6, Special Building Regulations.
   b. Chapter 8, Table T22-23-J.
8. SMACNA – Sheet Metal and Air Conditioning Contractors National Association, Inc.
   b. “Superstrut Seismic Restraint System” for pipes and conduits only, No. R0003.
10. National Electrical Contractors Association (NECA)

1.3 DEFINITIONS
   A. Fire stopping (Through-Penetration Protection System): Sealing or stuffing material or assembly placed in spaces between and penetrations through building materials to arrest movement of fire, smoke, heat, and hot gases through fire rated construction.
   B. EMT: Electrical metallic tubing.
   C. IMC: Intermediate metal conduit.
   D. RMC: Rigid metal conduit.

1.4 SYSTEM DESCRIPTION
   A. Fire stopping Materials: ASTM E119, ASTM E814, UL 263, UL 1479 to achieve fire ratings as noted on Drawings for adjacent construction, but not less than one (1) hour fire rating.
   B. Fire stopping Materials: ASTM E119, ASTM E814, UL 263, UL 1479, to achieve fire ratings of adjacent construction in accordance with FM, UL, WH Surface Burning: ASTM E84, UL 723 with maximum flame spread / smoke developed rating of 25/450.
   C. Fire stop interruptions to fire rated assemblies, materials, and components.

1.5 PERFORMANCE REQUIREMENTS
A. **Fire stopping:** Conform to applicable code FM, UL, or WH for fire resistance ratings and surface burning characteristics.

B. **Fire stopping:** Provide certificate of compliance from authority having jurisdiction indicating approval of materials used.

C. **Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.**

D. **Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.**

E. **Rated Strength:** Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

### 1.6 SUBMITTALS

A. Submit one (1) hard copy and one (1) electronic copy of the information below:

1. **Shop Drawings:** Signed and sealed by a qualified professional engineer. Indicate system layout with location and detail of trapeze hangers. Show fabrication and installation details and include the following:
   a. Trapeze hangers. Include Product Data for Components
   b. Steel slotted channel systems. Include Product Data for components.
   c. Equipment supports.

2. **Product Data:**
   a. **Hangers and Supports:** Submit manufacturers catalog data including load capacity.
   b. **Fire stopping:** Submit data on product characteristics, performance and limitation criteria.
   c. **Steel slotted support systems.**
   d. **Nonmetallic slotted support systems.**

3. **Fire stopping Schedule:** Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance rating of adjacent assembly.

4. **Design Data:** Indicate load carrying capacity of trapeze hangers and hangers and supports.

5. **Manufacturer’s Installation Instructions:**
   a. **Hangers and Supports:** Submit special procedures and assembly of components.
   b. **Fire stopping:** Submit preparation and installation instructions.

6. **Manufacturer’s Certificate:** Certify products meet or exceed specified requirements.

7. **Engineering Judgments:** For conditions not covered by UL or WH listed designs, submit judgments by licensed professional engineer suitable for presentation to authority having jurisdiction for acceptance as meeting code fire protection requirements.
8. Welding certificates.

1.7 QUALITY ASSURANCE

A. General:
   1. Anchor support, and brace all equipment and systems to resist seismic forces as specified hereinafter.
   2. Comply with CCR Title 24.
   3. Where anchorage support and bracing for various manufactured and systems are detailed and scheduled on the drawings, provide as shown.
   4. For anchorage, support and bracing not detailed, provide in accordance with the Certified Guidelines for Seismic Restraints.
   6. Comply with NFPA 70.

B. Loads to be transmitted to the structure at anchor points.
   1. Architects/Engineers must provide Anchorage and Construction Details to contractors prior to commencing work.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements as specified.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations as specified.

C. Sequence work to coordinate installation with other trades.

1.9 QUALIFICATIONS

A. The Manufacturer and Installer must have minimum 5 years’ documented experience in providing services as required by this section.

1.10 PRE-INSTALLATION MEETINGS

A. As per Project Meeting requirements.

1.11 DELIVERY, STORAGE, AND HANDLING

A. As per Material and Equipment requirements.

B. Accept materials on site in original factory packaging, labeled with manufacturer’s identification.

C. Protect from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original packaging.
D. Store products in accordance with manufacturer’s recommendation.

1.12 ENVIRONMENTAL REQUIREMENTS

A. As per Material and Equipment requirements.

B. Apply fire stopping materials when temperature of substrate material and ambient air is per recommended manufacturer levels.

C. Provide ventilation in areas to receive solvent cured materials.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Channel Supports

1. Unistrut
2. Superstrut
3. Steel City/Kindorf
4. B-Line Systems
5. Or approved equal

B. Fasteners

1. Caddy
2. Steel City
3. T&B
4. Tomic
5. Pentair Electrical & Fastening Solutions
6. Construction Engineered Attachment Solutions
7. Or approved equal

C. Expansion Bolts

1. Hilti Red Head
2. SMACNA approved type
3. Or approved equal

D. Concrete Fasteners

1. Phillips “Red-Head” WS series
2. Powder driven washers by Remington, Ramset or equal
3. Drilled Sleeve type expansion anchors, Ramset “Dynabolt” “Red-Head” RM series or equal.

2.2 CONDUIT SUPPORTS

A. Hanger Rods:

1. Threaded high tensile strength galvanized carbon steel with free running threads.
2. Zinc plated corrosion resistant rods.
B. Beam Clamps: Malleable Iron, with tapered hole in base and back to accept either bolt or hanger rod. Set screw: hardened steel single flange or double flange.
   1. Set screw type
   2. Hammer on flange type.

C. One-hole strap, steel or malleable iron, with malleable iron clamp-back spacer for surface mounted wall and ceiling applications.
   1. Use malleable strap with spacers for exterior and wet locations.
   2. Use Steel strap without spacers for interior locations.

D. Steel channel conduit strap for support from construction channel.

E. Steel conduit hanger for pendant support with threaded rod.

F. Steel wire conduit support strap for support from independent #12-gauge hanger wires.

G. All raceways systems shall be secured to building structures using specified fasteners, clamps and hangers spaced according to the NEC, except branch lighting circuits to Airport recessed ceiling fixtures that may be supported by suspended ceiling wires with approved spring clamps per the NEC.

H. Support single runs of conduit using one-hole pipe straps. Where run horizontally on walls in damp or wet locations, install “clamp backs” to space conduit off the surface.

I. Where practical, multiple conduit runs shall be supported using “trapeze” hangers fabricated from specified construction channel, mounted to 3/8” diameter, and threaded steel rods secured to building structures. Fasten conduit to construction channel with standard one-hole pipe clamps or the equivalent. Provide lateral seismic bracing for hangers.

J. Individual ½”, ¾” and 1” conduits installed above suspended ceilings may be attached to independent ceiling hanger wire using approved spring clamps.

K. Support exposed vertical conduit runs at each floor level, independent of cabinets or switches to which they run, by means of acceptable supports.

L. Fasteners and supports in solid masonry and concrete:
   1. Use steel or malleable iron concrete inserts set in place prior to placing the concrete.
   2. After concrete installation:
      a. Steel expansion anchors not less than 1/4” and not less bolt size not less than 1-1/8” embedment.
      b. Power set fasteners not less than 1/4” diameter with depth of penetration not less than 3”.
      c. Use vibration and shock resistant anchors and fasteners for attaching to concrete ceilings.

M. Hollow masonry: Toggle bolts are permitted. Bolts supported only by masonry block are not acceptable.

N. Metal structures: Use machine screw fasteners or other devices specifically designed and approved for
O. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16” diameter holes at a maximum of 8” o.c., in at least one surface.
   1. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
   2. Fitting and Accessory Materials: Same as channels and angles.
   3. Rated Strength: Selected to suit applicable load criteria.

P. Manufacturers
   1. Allied Support Systems; Power-Strut Unit
   2. Cooper B-Line, Inc.; A division of Cooper Industries.
   3. Fabco Plastics Wholesale Limited
   4. Seasafe, Inc.
   5. Or approved equal

Q. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

R. Raceway and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

S. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

T. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following.
   1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
      a. Manufacturers:
         1) Hilti Inc.
         2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
         3) MKT Fastening, LLC.
         4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
         5) Or approved equal.
   2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
   3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
   4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
   5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods:
   a. MSS SP-58; threaded steel, with adjusting and lock nuts; electroplated zinc finish.
   b. MSS SP-58; nonmetallic, with adjusting and lock nuts.

2.3 SLEEVES

A. Sleeves for conduit through Non Fire-Rated Floors: 18-gage thick galvanized steel.

B. Install sleeves for conduit through Fire Rated and Fire Resistive Floors and Walls, and Fire Proofing: Prefabricated fire rated sleeves including seals, UL listed.

C. Fire-stopping Insulation: Glass fiber type, non-combustible. Manufacturer recommended

2.4 MECHANICAL SLEEVE SEALS

A. Manufacturers:
   1. Thunderline Link-Seal, Inc.
   2. NMP Corporation
   3. Or approved equal

B. Product Description: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between object and sleeve, connected with bolts and pressure plates causing rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

2.5 FIRESTOPPING

A. Manufacturers:
   1. Dow Corning Corp.
   2. Fire Trak Corp.
   3. Hilti Corp
   4. International Protective Coating Corp
   5. 3M Fire Protection Products
   7. Or approved equal

B. Product Description: Different types of products by multiple manufacturers are acceptable as required to meet specified system description and performance requirements; provide only one type for each similar application.

   1. Silicone Fire stopping Elastomeric Fire stopping: Single component silicone elastomeric compound and compatible silicone sealant.


   3. Formulated Fire stopping Compound of Incombustible Fibers: Formulated compound mixed with incombustible non-asbestos fibers.
4. Fiber Stuffing and Sealant Fire stopping: Composite of fiber stuffing insulation with silicone elastomer for smoke stopping.

5. Mechanical Fire stopping Device with Fillers: Mechanical device with incombustible fillers and silicone elastomer, covered with sheet stainless steel jacket, joined with collars, penetration sealed with flanged stops.

6. Intumescent Fire stopping: Intumescent putty compound which expands on exposure to surface heat gain.

7. Fire Stop Pillows: Formed mineral fiber pillows.

C. Color: As selected from manufacturer’s full range of colors.

2.6 FIRESTOPPING ACCESSORIES

A. Primer: Type recommended by fire stopping manufacturer for specific substrate surfaces and suitable for required fire ratings.

B. Dam Material - Permanent:
   1. Mineral fiberboard.
   3. Alumina silicate fire board.

C. Installation Accessories: Provide clips, collars, fasteners, temporary stops or dams, and other devices required to position and retain materials in place.

D. General:
   1. Furnish UL listed products.
   2. Select products with rating not less than rating of wall or floor being penetrated.

E. Non-Rated Surfaces:
   1. Stamped steel, chrome plated, hinged, split ring escutcheons or floor plates or ceiling plates for covering openings in occupied areas where conduit is exposed.
   2. For exterior wall openings below grade, furnish modular mechanical type seal consisting of interlocking synthetic rubber links shaped to continuously fill annular space between conduit and cored opening or water-stop type wall sleeve.

2.7 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   1. Available Manufacturers:
      a. Allied Tube & Conduit.
      b. Cooper B-Line, Inc.; a division of Cooper Industries.
      c. ERICO International Corporation.
      d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.
g. Wesanco, Inc.
h. Or approved equal.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA- 4.

3. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   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) Hilti Inc.
      2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
      4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened Portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

   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) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti Inc.
      4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTMA 325.
6. Toggle Bolts: All-steel springhead type.

2.8 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in "Metal Fabrications" for steel shapes and plates.

PART 3 – EXECUTION

3.1 EXAMINATION

A. As per Job Site Administration requirements.
B. Verify openings are ready to receive sleeves.
C. Verify openings are ready to receive fire stopping.

3.2 PREPARATION

A. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter affecting bond of fire stopping material.
B. Remove incompatible materials affecting bond.
C. Install backing or damming materials to arrest liquid material leakage.
D. Obtain permission from Architect/Engineer before using powder-actuated anchors.
E. Do not drill or cut structural members.
F. Verify that mounting surfaces are ready to receive support and attachment components.
G. Verify that conditions are satisfactory for installation prior to starting work.

3.3 INSTALLATION – HANGERS AND SUPPORTS

A. Anchors and Fasteners:
   1. Concrete Structural Elements: Provide precast inserts, expansion anchors.
   2. Steel Structural Elements: Provide beam clamps, steel ramset fasteners, and welded fasteners.
   3. Concrete Surfaces: Provide expansion anchors.
5. **Solid Masonry Walls:** Provide expansion anchors and preset inserts.

6. **Sheet Metal:** Provide sheet metal screws.

7. **Wood Elements:** Provide wood screws.

**B. Inserts:**

1. Install inserts for placement in concrete forms.

2. Install inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4”.

4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut.

**C.** Install conduit and raceway support and spacing in accordance with NEC.

**D.** Do not fasten supports to pipes, ducts, mechanical equipment, or conduit.

**E.** Install multiple conduit runs on common hangers.

**F.** Supports:

1. Fabricate supports from structural steel or formed steel channel. Install hexagon head bolts to present neat appearance with adequate strength and rigidity. Install spring lock washers under nuts.

2. Install surface mounted cabinets and panel boards with minimum of four anchors.

3. In wet and damp locations install steel channel supports to stand cabinets and panel boards one inch (1”) off wall.

4. Support vertical conduit at every floor.

### 3.4 INSTALLATION – FIRESTOPPING

**A.** Install material at fire rated construction perimeters and openings containing penetrating sleeves, piping, ductwork, conduit and other items, requiring fire stopping.

**B.** Apply primer where recommended by manufacturer for type of fire stopping material and substrate involved, and as required for compliance with required fire ratings.

**C.** Apply fire stopping material in sufficient thickness to achieve required fire and smoke rating to uniform density and texture.

**D.** Place foamed material in layers to ensure homogenous density, filling cavities and spaces. Place sealant to completely seal junctions with adjacent dissimilar materials.

**E.** Fire Rated Surface:

1. Seal opening at floor, wall, partition, and/or ceiling, as follows:
a. Install sleeve through opening and extending beyond minimum of one inch (1") on both sides of building element.

b. Size sleeve allowing minimum of one inch (1") void between sleeve and building element.

c. Pack void with backing material.

d. Seal ends of sleeve with UL listed fire resistive silicone compound to meet fire rating of structure penetrated.

2. Where cable tray, conduit, wire way or trough penetrates fire rated surface, install fire stopping product in accordance with manufacturer's instructions.

F. Non-Rated Surfaces:

1. Seal opening through non-fire rated wall, partition floor, and/or ceiling opening as follows:
   a. Install sleeve through opening and extending beyond minimum of one inch (1") on both sides of building element.
   b. Size sleeve allowing minimum of one inch (1") void between sleeve and building element.
   c. Install type of fire stopping material recommended by manufacturer.

2. Install escutcheons, floor plates or ceiling plates where conduit, penetrates non-fire rated surfaces in occupied spaces. Occupied spaces include rooms with finished ceilings and where penetration occurs below finished ceiling.

3. Exterior wall openings below grade: Assemble rubber links of mechanical seal to size of conduit and tighten in place, in accordance with manufacturer's instructions.

4. Interior partitions: Seal pipe penetrations at equipment room. Apply sealant to both sides of penetration to completely fill annular space between sleeve and conduit.

3.5 INSTALLATION – EQUIPMENT BASES AND SUPPORTS

A. Using templates furnished with equipment, install anchor bolts, and accessories for mounting and anchoring equipment.

B. Install surface-mounted cabinets and panel boards with minimum of 4 anchors.

C. Construct supports of structural steel or formed steel channel. Brace and fasten with flanges bolted to structure.

D. Support Installation:

1. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

2. Raceway Support Method: In addition to methods described in ENCA 1, EMT, and IMC may be supported by openings through structure members, as permitted by NFPA 70.

3. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads per NEC.

4. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following...
methods unless otherwise indicated by code:

a. To Wood: Fasten with lag screws or through bolts.

b. To New Concrete: Anchor bolt to concrete inserts.
   1) Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2) Install anchor bolts to elevations required for proper attachment to supported equipment.
   3) Install anchor bolts according to anchor-bolt manufacturer’s written instructions.

c. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.

d. To Existing Concrete: Expansion anchor fasteners.

e. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4” thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4” thick.

f. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.

g. To Light Steel: Sheet metal screws.

h. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panel boards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

5. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

E. Installation of Fabricated Metal Supports

1. Comply with installation requirements “Metal Fabrications” requirements for site-fabricated metal supports.

2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

3. Field Welding: Comply with AWS D1.1/D1.1M.

F. Painting

1. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

2. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

3. Touchup: Comply with requirements in Painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
4. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

G. NOTE: Fire proofing must be patched after installation of hangers/anchors.

3.6 INSTALLATION – SLEEVES

A. Exterior watertight entries: Seal with adjustable interlocking rubber links.
B. Conduit penetrations not required to be watertight: Fill with silicon foam.
C. Set sleeves in position in forms. Provide reinforcing around sleeves.
D. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
E. Where conduit or raceway penetrates floor, ceiling, or wall, close off space between conduit or raceway and adjacent work with fire stopping insulation and caulk airtight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
F. Install escutcheons at finished surfaces that are below the ceiling.

3.7 FIELD QUALITY CONTROL

A. As per Quality Control requirements.
B. Inspect installed fire stopping for compliance with specifications and submitted schedule.
C. Inspect support and attachment components for damage and defects.
D. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
E. Correct deficiencies and replace damaged or defective support and attachment components.

3.8 CLEANING

A. As per Contract Closeout requirements.
B. Clean adjacent surfaces of fire stopping materials.

3.9 PROTECTION OF FINISHED WORK

A. As per Contract Closeout requirements.
B. Protect adjacent surfaces from damage by material installation.

END OF SECTION 26 05 29
SECTION 26 05 33 – RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Provision: Applicable provisions of General Electrical Requirements, become part of this section as if repeated herein.

B. Work included:
   1. Installation of all necessary outlet boxes for wiring devices, lighting fixtures, and signal equipment as noted on drawings.
   2. Installation of junction boxes as required for the consolidation of conduit runs.
   3. Installation of pull boxes as necessary to aid in pulling conductors.
   4. Installation of conduit transition cabinets as noted on the drawings.

C. Section Includes
   1. Wall and Ceiling outlet Boxes
   2. Pull and Junction Box
   3. Raceways
   4. Enclosures
   5. Cabinets for electrical wiring

1.2 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM) Publications:
   1. A123/A123M-15: Zinc Coating (Hot Dip) on Assembled Steel Products, Specifications

B. Federal Specifications (FS):
   1. A-A-5056: Conduit Outlet Boxes, Bodies, and Entrance Caps, Electrical, Cast Metal
   2. A-A-59214: Junction Box, Extension, Junction Box Cover, Junction Box (Steel, Cadmium or Zinc Coated)

C. Underwriters Laboratories, Inc. (UL) Publications:
   1. UL 50-1987: Electrical Cabinets and Boxes, Non-Environmental Considerations.
   2. UL 50E: Electrical Cabinets and Boxes, Environmental Considerations.
   3. 514-1987: Outlet Boxes and Fittings
D. National Fire Protection Association (NFPA)
E. National Electrical Code (NEC)
F. Underwriters Laboratories (UL)
G. National Electrical Contractors Association (NECA)
H. National Electrical Manufacturers Association (NEMA) Standards
I. American National Standards Institute (ANSI)
J. Society of Cable Telecommunications Engineers (SCTE)
K. International Organization for Standardization (ISO)
L. National Institute of Standards and Technology (NIST)

1.3 DEFINITIONS
A. EMT: Electrical metallic tubing.
B. ENT: Electrical nonmetallic tubing.
C. EPDM: Ethylene-propylene-diene terpolymer rubber.
D. FMC: Flexible metal conduit.
E. IMC: Intermediate metal conduit.
F. LFMC: Liquid-tight flexible metal conduit.
G. NBR: Acrylonitrile-butadiene rubber.
H. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS
A. Submit manufacturer’s catalog data on all NEMA boxes.
B. Submit detailed shop drawings of boxes proposed for proposed modifications to existing boxes.
C. Product Data: For surface raceways, wire ways and fittings, floor boxes, hinges-cover enclosures, and cabinets.
D. LEED Submittals:
   1. Product Data for Credit IEQ 4: For solvent cements and adhesive primers, documentation including printed statement of VOC Content.
   2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers,
documentation indicating that products comply with the testing and product requirements of the California Department of Health Services’ “Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers.”

E. Samples for Initial Selection: For wire ways and surface raceways with special factory-applied texture and color finishes.

1.5 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.

C. Source Quality Control for Underground Enclosures

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

PART 2 – PRODUCTS

2.1 OUTLET, JUNCTION AND PULL BOXES

A. Sheet metal boxes: Sheet metal boxes shall conform to UL 50, with a hot-dipped galvanized finish conforming to ASTM. A123/A123M-15 Boxes and box extension rings shall be provided with knockouts. Boxes shall be formed in one piece from carbon-steel sheets. Outlet boxes shall not be less than 4” square and 1 ½” deep. Gangable and through-wall types are not acceptable. Boxes shall conform to Federal Specification A-A-59214A-A-59214 and U 514.

B. Junction boxes and Pull Boxes: Boxes shall be fabricated from carbon steel per UL 50. Boxes shall be welded construction with all seams or joints closed and reinforced. Boxes shall be galvanized after construction. Boxes intended for outdoor use shall be cast metal with threaded hubs and neoprene covers. Cover retention shall be by corrosion resistant stainless steel screws.

1. All boxes for wiring operating at 601 volts or higher shall be constructed without hinges and shall be padlock-able.

2. All boxes and cabinets shall be securely fastened to building structural members so as to prevent movement in any direction. Boxes shall not be supported by lighting fixtures, suspended ceiling support wires or freely hanging rods.
   a. Covers of boxes and cabinets mounted in horizontal plane (top or bottom) shall either weigh not more than 40 pounds or shall require not more than 40 pounds of force to open or close.
   b. Covers of boxes and cabinets mounted in vertical plane (front, back, sides) shall either
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weigh not more than 40 pounds or shall require not more than 60 pounds of force to open or close. All covers over 30 pounds shall be furnished with angle support at bottom to carry weight of cover for assembly.

c. Covers of boxes and cabinets weighing more than 30 pounds shall be provided with lifting handles or some means of grasping other than edges.

3. Provide additional stiffening or reinforcing in existing pull boxes where the box shall conform to the strength requirements of the NEC and UL 50.

2.2 UNDERGROUND DUCT GENERAL REQUIREMENT

A. Cross duct below gas piping.

B. Slope duct to manholes.

C. Route duct as straight as possible between points.

D. All elbows shall be same material as conduit.

E. Transition duct to PVC-coated rigid metal or rigid conduits coming into buildings at 5 feet from building outside wall.

2.3 METAL CONDUIT AND TUBING

A. Available Manufacturers:
   1. AFC Cable Systems, Inc.
   2. Alflex Inc.
   3. Allied Tube & Conduit; a Tyco International Ltd. Co.
   4. Anamet Electrical, Inc.; Anaconda Metal Hose.
   5. Electri-Flex Co.
   7. Maverick Tube Corporation.
   10. Or approved equal.

B. Rigid Steel Conduit: ANSI C80.1.

C. IMC: ANSI C80.6.

D. EMT: ANSI C80.3.

E. FMC: Zinc-coated steel. Reduced wall or thin wall FMC shall not be used.

F. LFMC: Flexible Steel conduit with PVC jacket.

G. Fittings for Conduit (Including all Types and Flexible and Liquid tight), EMT: NEMA FB 1 and UL 514B; listed for type and size raceway with which used, and for application and environment in which installed.
   1. Fittings for EMT: Steel, set-screw or compression type.
H. Joint Compound for IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.4 NONMETALLIC CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. AFC Cable Systems, Inc.
   2. Anamet Electrical, Inc.; Anaconda Metal Hose.
   3. Arnco Corporation.
   4. CANTEX Inc.
   7. ElecSYS, Inc.
   8. Electri-Flex Co.
   9. Lamson & Sessions; Carlon Electrical Products.
  10. Manhattan/CDT/Cole-Flex.
  11. RACO; a Hubbell Company.
  12. Thomas & Betts Corporation.

B. ENT: Comply with NEMA TC 13 and UL 1653.

C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

D. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

2.5 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

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. Arnco Corporation.
   2. Endot Industries Inc.
   3. IPEX Inc.
   4. Lamson & Sessions; Carlon Electrical Products.

B. Description: Comply with UL 2024; flexible type, approved for plenum installation.

2.6 METAL WIREWAYS

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. Cooper B-Line, Inc.
   2. Hoffman.
   3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, UL 870 and NEMA 250, Type 1 or 3R, unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down
straps, end caps, and other fittings to match and mate with wire ways as required for complete system.

D. Wire way Covers: Hinged type.

E. Finish: Manufacturer’s standard enamel finish.

2.7 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer’s standard enamel finish in color selected by Architect.

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

      a. Thomas & Betts Corporation.
      c. Wiremold Company (The); Electrical Sales Division.

2.8 BOXES, ENCLOSURES, AND CABINETS

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. Cooper Cross-Hinds; Div. of Cooper Industries, Inc.
   2. EGS/Appleton Electric.
   7. RACO; a Hubbell Company.
   10. Spring City Electrical Manufacturing Company.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1 and UL 514A.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

D. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular.

E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

F. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1 and UL1773, cast aluminum with gasketed cover.
G. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

H. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer’s standard enamel.

I. Cabinets:
   1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer’s standard enamel.
   2. Hinged door in front cover with flush latch and concealed hinge.
   3. Key latch to match panel boards.
   4. Metal barriers to separate wiring of different systems and voltage.
   5. Accessory feet where required for freestanding equipment.

2.9 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Description: Comply with SCTE 77.
   2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
   3. Cover: Weatherproof, secured by tamper-resistant looking devices and having structural load rating consistent with enclosure.
   4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of ½.
   6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

B. Polymer-Concrete Hand holes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Armorcast Products Company.
      b. Carson Industries LLC.
      c. CDR Systems Corporation.
      d. NewBasis.

C. Fiberglass Hand holes and Boxes: Molded or fiberglass-reinforced polyester resin, with covers of polymer concrete.
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering
products that may be incorporated into the Work include, but are not limited to, the following:

a. Carson Industries, LLC.
b. Christy Concrete Products.
c. Nordic Fiberglass, Inc.

PART 3 – EXECUTION

3.1 INSTALLATION

3.2 NOTE: Pull cans, patchcord access, and equipment panels for base building/Airport equipment shall not be located in tenant lease areas. Access for base building equipment shall outside of tenant area footprints.

A. Outlet Boxes:

1. Provide fixture outlets with proper fixture connectors.
2. Box mounting height shall be dictated by the wiring device enclosed.
3. Blanking covers shall be installed on all unused openings.
4. Sheet metal boxes shall be used in dry locations where the conduit system is routed concealed in the walls and ceilings.
5. Cast metal or molded non-metallic surface mounted boxes shall be used in exterior and/or in all wet locations.
6. Bonding jumpers shall be used around all concentric or eccentric knockouts.
7. Boxes shall be securely mounted to the building structure independent or conduits entering or exiting the boxes.

B. Junction Boxes and Pull Boxes:

1. Boxes shall be installed where required and where indicated on the Drawings.
2. Boxes shall be readily accessible.
3. Boxes shall not be installed in furnished areas.
4. Pull boxes shall be installed per NEC.
5. Box dimensions shall be in accordance with size and quantity of conductors and conduits entering and leaving box per NEC Article 370 requirements.

NOTE: Field installation shall be instructed NOT to install any pull boxes within the tenant space footprint.

C. Miscellaneous

1. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
2. Keep raceways at least 6” away from parallel runs of flues and steam or hot-water pipes.
3. Complete raceway installation before starting conductor installation.

4. Support raceways as specified in Section 26 05 29 “Hangers and Supports for Electrical Systems.”

5. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

6. Install no more than 360 degrees of bends in any conduit run except for communications conduits, for which fewer bends are allowed, per NEC.

7. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

8. Raceways Embedded in Slabs:
   a. Run conduit larger than one inch (1") trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
   b. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
   c. Change from ENT to RNC, Type EPC-40-PVC, or IMC before rising above the floor.

9. Threaded Conduit Joints Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer’s written instructions.

10. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

11. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12” of slack at each end of pull wire.

12. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:
   a. Three-fourths inch (¾") Trade Size and Smaller: Install raceways in maximum lengths of 150’.
   b. One inch (1”) Trade Size and Larger: Install raceways in maximum lengths of 150’.
   c. Install with a maximum of 360 degrees of bends per NEC.

13. Expansion-Joint Fittings: Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 ºF and that has straight-run length that exceeds 25 feet. Install in each run of aboveground EMT conduit that is located where environmental temperature change may exceed 100 ºF and that has straight-run length that exceeds 100 feet. Install expansion fittings at all locations where conduits cross building or structure expansion joints.

14. Flexible Conduit Connections: Use maximum of 72” of flexible conduit for recessed and semi recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
   a. Use LFMC in damp or wet locations.

15. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block,
and install box flush with surface of wall.

16. Set metal floor boxes level and flush with finished floor surface.

D. Raceway Application

1. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
   a. Exposed Conduit: GRC or RNC, Type EPC-40 PVC.
   b. Concealed Conduit, Aboveground: GRC
   c. Underground Conduit: RNC Type EPC-40 PVC shall be concrete encased with reinforcement.
   d. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC, FSC, AFC.
   e. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R., unless otherwise indicated on Drawings
   f. Application of Hand holes and Boxes for Underground Wiring:
      1) Hand holes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Non-deliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
      2) Hand holes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Non-Deliberate Loading by Vehicles: Polymer-concrete units, SCTE 77, Tier 8 structural load rating.
      3) Hand holes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin structurally tested according to SCTE 77 with 3000-lbf vertical loading.

2. Comply with the following indoor applications, unless otherwise indicated:
   a. Exposed, Not Subject to Physical Damage: EMT.
   b. Exposed, Not Subject to Severe Physical Damage: EMT.
   c. Exposed and Subject to Severe Physical Damage: GRC.
   d. Concealed in Ceilings and Interior Walls and Partitions: EMT.
   e. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
   f. Damp or Wet Locations: PVC-Coated Galvanized Rigid Steel
   g. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway.
   h. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: EMT.
   i. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: EMT.
j. Boxes and Enclosures: NEMA 250, Type 1, unless otherwise indicated on Drawings.


4. Raceway Fittings: Compatible with raceways and suitable for use and location.
   a. Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
   b. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

E. Installation of Underground Conduit

1. Install underground conduits specified in Section 26 05 43 “Underground Ducts and Raceways for Electrical Systems.”

F. Installation of Underground Hand holes and Boxes

1. Install hand holes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

2. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from ½” sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

3. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1" above finished grade.

4. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

5. Field-cut openings for conduits according to enclosure manufacturer’s written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

Note: Conduits for future use penetrating floors must be capped

G. Fire stopping

1. Apply fire stopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Fire stopping materials and installation requirements are specified in Division 7 Section “Fire stopping Systems.”

H. Protection

1. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
   a. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   b. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 05 33
SECTION 26 05 34 – CONDUIT, RACEWAYS AND FITTINGS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Provisions: Applicable provisions of Basic Electrical Materials and Methods become a part of this Section as if repeated herein.

1.2 REFERENCE STANDARDS

A. American National Standards Institute (ANSI) Publications:
   2. C80.1-1983: Specifications for Zinc Coated Electrical Metallic Tubing

B. Federal Specifications (FS):
   1. FS W-C-1094: W-C-1094A Rigid Nonmetallic Conduit and Fittings
   2. FS WW-C-563: WW-C-563A Electrical Metallic Tubing
   3. FS WW-C-566: WW-C-566C Flexible Metal Conduit

C. National Electrical Manufacturers Association (NEMA) Publications:
   1. RN 1-1980: Polyvinyl Chloride Externally Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing
   2. TC 6-1983: PVC and ABS Plastic Utilities Duct for Underground Installation
   3. TC 14-1984: Filament-Wound Reinforced Thermosetting Resin Conduit

D. Underwriters Laboratories (UL) Standards:
   1. 6-1981 (R1983) : Rigid Metal Electrical Conduit
   2. 360-1980 (R1982): Liquid-Tight Flexible Steel Electrical Conduit
   4. 797-1983: Electrical Metallic Tubing

E. National Electrical Code (NEC)

1.3 SUBMITTALS

A. Catalog Date: Provide manufacturer’s descriptive literature.

B. Single Submittal: One (1) hard copy and one (1) electronic copy is required for all products covered by this Section.

1.4 LOCATIONS
A. As per General Electrical Requirements. Refer for definitions of types of locations.

PART 2 – PRODUCTS

2.1 CONDUIT, RACEWAYS

A. General: Galvanized rigid steel conduit shall be used in all conduit systems, except where otherwise shown on the Drawings, where flexible conduit is required, or where these Specifications require, or allow the use of electric metallic tubing (EMT), or MC cable, or duct.

1. Conduit runs concealed in or behind walls, above ceilings, or exposed on walls and ceilings less than 5 feet above finished floors and subject to mechanical damage or corrosion shall be rigid steel conduit, unless noted otherwise.

2. The minimum size raceway shall be 3/4”.

B. Galvanized Rigid Steel Conduit (GRS) shall be hot-dip galvanized after fabrication, conforming to ANSI C80.1 and UL 6, with chromated protective layer, ETL verified to Intertek ETL SEMKO high temperature H2O. Couplings shall be threaded type. Where PVC coated rigid steel conduit is called for, it shall be hot-dip galvanized, conforming to NEMA RN 1, with factory-applied PVC coating 40 mils thick. PVC Coating Adhesion Test Procedure for 200 hours.

C. Flexible Conduit:

1. Flexible metal conduit shall be liquid-tight or flexible aluminum conduit, shall have low-smoke, low-flame and moisture/oil proof non-metallic insulation jacket extruded over a galvanized, flexible steel conduit, and shall conform to UL 360.

2. Flexible conduit for hazardous locations shall be UL listed for the applicable class, Division, and Group.

D. Electrical Metallic tubing (EMT) shall be galvanized thin wall conduit conforming to UL 797.

E. Metal Clad Cables (MC Cable) shall conform to UL 1569 and branch circuit conductors shall not be larger than No. 10 AWG.

F. PVC coated RGS shall be hot-dip galvanized conforming to NEMA RN 1, with factory-applied PVC coating 40 mils thick and shall be ETL Verified PVC-001.

G. Fittings for PVC coated galvanized rigid steel conduit shall be hot-dipped galvanized steel fittings with 40 mil thick PVC coating. Manufacturer shall be Robroy Industries, Kor-Kap, ADP, or approved equal.

H. All conduit for Fire Alarm Systems shall be red.

2.2 MC Cable

A. GENERAL: MC CABLE IS NOT APPROVED FOR USE IN THE FOLLOWING CONDITIONS/SYSTEMS:

1. All Fire/Life Safety electrical systems shall be in metallic raceway.

2. All Security and camera systems shall be in metallic raceway.

3. All exterior locations.
4. Baggage handling areas.
5. Embedment in concrete or below grade.

B. Acceptable Use of MC Cables

1. MC Cable for Emergency Lighting is allowed.

2. Locations:
   a. Electrical Rooms, Mechanical Rooms, Special System Rooms and all Equipment Rooms.
      1) Maximum 6’ length to supply luminaires.
   
   b. General Interior Areas
      1) Shall be concealed or located above accessible ceilings.


4. All MC Cable penetration through fire rated walls must conform to all NEC or CBC requirements
   and must be a listed penetration system.

5. Type MC Cable shall provide dedicated ground-fault current path with a dedicated ground
   insulated ground wire and the metallic sheath shall be listed as an equipment grounding
   conductor – for safety and system reliability. Sheathing shall be aluminum. Connectors shall be
   steel and appropriate for use with the Type MC Cable.

6. Lighting circuits may use MC Luminary or approved equivalent. Sheathing shall be aluminum.
   Connectors shall be steel and appropriate for use with the Type MC Cable.

7. Limited to lengths of 100 feet or less from the furthest outlet to a raceway wiring method.

8. Metallic conduits shall be used between junction boxes. Junction boxes shall be identified as to
   panelboard and circuit.

9. Circuit conductors in individual cables and enclosures shall be supplied by only one panelboard.

10. Continuous Conductor Color coding is required for MC Cable per A&E Standards. No re-
      identification of conductors allowed.

11. Where located above accessible tile suspended ceilings, separation shall be maintained between
    cables containing circuits from separate panelboards, and cables shall be identified by system
    by continuous marking or approved tagging every 10’. Electric Shop shall provide color coding
    directions.

12. In most applications, MC Cables shall be used for individual devices. However, “daisy chaining”
    (multiple devices wired together in sequence or in a ring) for branch circuits will be acceptable
    for Airport wall outlets where required by the available pathways. “Daisy chaining” for lighting is
    acceptable.

13. Where practical, wall outlets shall be supplied from individual junction boxes located above an
    accessible ceiling in the same room or area as the wall outlet.
C. SUPPORT METHODS

1. Outlet boxes supplied by MC Cable mounted in finished surfaces shall be rigidly secured to the studs or framing members with clamps, anchors or fittings identified for the application. Kick plates that do not provide rigid securement to studs or framing members are not acceptable.

2. Cables installed above suspended ceiling shall be supported from the structure above, but may not be supported using wires fastened between the ceiling grid and the structure above. Cables shall be fastened to slick rod or approved equal using Caddy k-series clips or equal.

3. Junction and pull boxes shall not be fastened to a suspended ceiling grid and shall be separately supported by building structure. Where deemed appropriate to meet seismic requirements, the use of power actuated fasteners from building structure will be acceptable. If required to meet seismic requirements, support from building structure shall be 3/8” diameter all thread rod as a minimum.

2.3 CONDUIT SUPPORTS

A. Supports for individual conduits shall be galvanized malleable iron one-hole type with conduit back spacer, unless noted on drawings.

B. Supports for multiple conduits shall be hot-dip galvanized Unistrut or Superstrut channels, or approved equal. All associated hardware shall be of the same material as the conduit support system.

C. All channels, threaded rods, nuts and clamps in corrosive areas shall be of epoxy resin reinforced fiberglass material.

D. All channels, threaded rods, nuts and clamps in corrosive areas shall be of epoxy resin reinforced fiberglass material.

E. Power-actuated fasteners can be used in conduit support assemblies if approved by Owner.

2.4 FITTINGS

A. Fittings for use with rigid steel shall be hot dipped galvanized steel or galvanized cast ferrous metal; access fittings shall have gasketed cast covers and be Crouse Hinds Condulets, Appleton Unilets, or equal. Provide threaded-type couplings and connectors; set-screw type and compression-type are not acceptable.

B. Fittings for use with nonmetallic duct shall be PVC and have solvent-weld type conduit connections. If such are not available, then the Specification for rigid steel fittings shall apply.

C. Fittings for flexible conduit shall be Appleton Type ST, O-Z Gedney Series 4Q, or approved equal.

D. Union couplings for conduits shall be the Erickson type and shall be Appleton Type EC, O-Z Gedney 3-piece Series 4, or approved equal. Thread less couplings shall not be used.

E. Bushings:

1. Bushings shall be the insulated type.

2. Bushings for rigid steel or IMC shall be hot dip galvanized insulated type per NEC, O-Z Gedney
Type HBLG, Appleton Type GIB, or approved equal.

F. Conduit seals shall have zinc electroplate and shall be Crouse-Hinds Type EYS; Appleton Type EYS, ESU or EY series; or approved equal.

G. Fittings for EMT shall be all steel water tight compression type. Connectors shall be insulated throat type. Drive-on, crimp, or spring fittings are not acceptable.

2.5 CONDUIT SEALANTS

A. Moisture Barrier Types: Sealant shall be a non-toxic, non-shrink, non-hardening, putty type hand applied material providing an effective barrier under submerged conditions.

B. Fire Retardant Types: Fire stop material shall be a reusable, non-toxic, asbestos-free, expanding, putty type material with a 3-hour rating in accordance with UL Classification 35L4.

PART 3 – EXECUTION

3.1 CONDUIT, RACEWAY AND FITTING INSTALLATION

A. From pull point to pull point, the sum of the angles of all of the bends and offsets shall not exceed 360 degrees per NEC.

B. At all boxes and equipment, provide insulated type metallic bushings for metallic conduits. Bond together all conduits per NEC.

C. Provide flexible conduit in lengths of not more than 24” at connections to motors, valves and any equipment subject to vibration or relative movement.

D. Conduits embedded in concrete floors on grade shall be installed between grids of reinforcing steel, or shall be encased below the floors, provided the concrete is thickened in a manner satisfactory to the Structural Engineer. Installation of conduit below the bottom of this slab is not acceptable; embedding or encasing is required.

E. Provide galvanized rigid steel factory elbows for GRS raceways.

F. Underground Raceway: Slope all underground raceways to provide drainage; for example, slope conduit from one pull box to the next pull box located down-the-line.

G. Properly support all conduits as required by NEC. Run all conduits exposed except where the Drawings, indicate that they are to be embedded in the floor slab, walls, or ceiling, or to be installed underground.

1. Exposed Conduits: Support exposed conduits within one foot of any outlet and at intervals not exceeding NEC requirements; wherever possible, group conduits together and support on common supports. Support exposed conduits fastened to the surface of the concrete structure by one-hole clamps, or with channels. Use conduit spacers with one- hole clamps. Coordinate conduit locations with piping, equipment, fixtures, and with structural and architectural elements. Conduits attached to walls or columns shall be as unobtrusive as possible and shall void windows. Run all exposed conduits parallel to building lines. Group together exposed conduits in horizontal runs located away from walls and support on trapeze hangers. Arrange such conduits uniformly and neatly. Trapeze hangers shall consist of
channels of adequate size, suspended by means of rods or other suitable means from the ceiling or from pipe hangers. Install such runs so as not to interfere with the operation of valves or any other equipment, and keep at least 6" clear of any pipe that may operate at more than 100 °F. Treat cut surfaces or damaged ends with corrosion-resistant coatings such as “Devcon Z,” prepared by Subox Coatings; “Galvanox - Type 1,” prepared by: Pedley-Knowles; or approved equal. Application shall follow manufacturer’s recommendation.

2. Conduits Embedded in Concrete: Provide concrete cover at least equal to that of the reinforcing steel, space per NEC except where they cross at angles greater than 45 degrees, and install so as not to reduce the structural integrity of the concrete element or per the recommendations of the project’s Structural Engineer.

H. When expansion joints are crossed, whether conduit is embedded or exposed, provide watertight expansion and deflection fittings and bonding jumpers. In hazardous locations, provide Crouse-Hinds UNF/UNV, Appleton, or equal. In unclassified locations, provide Crouse-Hinds XD, Appleton, or equal.

I. Spare Raceways: After completing a conduit or duct run between boxes, manholes or hand holes prove the integrity of the conduit run. Use an air compressor to blow in a pull-line, then use the pull-line to pull a mandrel through the entire conduit run. Install a new 1/4"; nylon, 200 pound test pull-line and plug the ends of the conduit with conduit cap plugs.

J. All conduit penetrations through interior walls and floors shall be sealed with fire retardant type applicable conduit sealant.

K. Conduit Seals:
   1. Moisture Seals: Provide in accordance with NEC.
   2. Gas Seals: Provide in accordance with NEC.

L. Conduit in finished areas shall be installed concealed behind the finished walls. Coordinate work as required.

M. Flexible metallic conduit shall have a maximum length of 6 feet. Flexible metallic conduit shall not be considered as a ground conductor. Flexible metallic conduit shall only be installed in exposed or accessible locations.

N. Cut EMT shall be reamed to remove all burrs.

O. All exposed conduits for medium voltage cables shall be identified “High Voltage” every 20 feet.

END OF SECTION 26 05 34
SECTION 26 05 33.13 – PVC COATED GALVANIZED RIGID STEEL CONDUIT

PART 1 – GENERAL

1.1 REQUIREMENTS

A. Under this Section, the Contractor shall furnish and install all conduits, with conduit fittings coupling, connectors, adapters, plugs, spacers, and all appurtenances to complete the installation of all electrically operated equipment as specified herein and as required.

B. Contractor shall install these conduits in such a manner to avoid all interferences.

1.2 REFERENCES

A. Comply with the latest versions of the following Standards:
   1. American National Standards Institute (ANSI)
   2. National Electrical Manufacturers Association (NEMA)
   3. Underwriters Laboratories (UL)
   4. National Electrical code (NEC)
   5. ETL Markings

1.3 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions. The following tests are required:

1. Witnessed shop tests
   a. None required.

2. Field tests
   a. Field testing shall be done in accordance with the requirements specified in the General Conditions, and General Electrical Requirements.
   b. All conduit shall be tested to ensure continuity and the absence of obstructions by pulling through each conduit a swab followed by a mandrel 85% of the conduit inside diameter. After testing, all conduits shall be capped after installation of suitable pulling tape.

1.4 SUMMARY

A. For work on Airfield, contractor shall use equipment in reliable operating condition, capable of maintaining production schedule. Engineer reserves the right to require backup equipment be made available, at no cost to the Airport, throughout the remainder of project work.

B. This specification applies to all items not covered by the Part 3 of this section. Under this section, the Contractor shall furnish all equipment, labor, material, and incidentals to perform, execute, and complete work as shown on the plans and in these specifications at no additional cost to the Airport,
including the following:

1. Clearing of the site.
2. Stripping of vegetation.
3. Unclassified excavation of soil material.
4. Trenching and potholing.
5. Shoring or sloping for excavation.
6. Benching or stepping.
7. Scarifying and disking.
8. Rough grading.
10. Performing groundwater testing, and testing, removing, hauling, and disposing of excavated material to approved site outside Airport property.
11. Removing, hauling, and disposing of excavated material and/or stripped vegetation to approved site outside Airport property.
12. Hauling and depositing material to designated site within Airport property.
13. Protection of subgrade.

1.5 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Submittals, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable Specification section.

PART 2 – PRODUCTS

2.1 GENERAL

A. The material covered by this Specification is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

B. All components of the conduit system shall be of the same material of construction. Galvanized Rigid Steel (GRS) PVC coated conduit systems shall include factory coated fittings couplings, connectors, and other components compatible with and approved for coated conduit systems.

1. PVC coated rigid steel conduit shall be furnished and installed as specified herein and indicated on the Drawings. The product shall be rigid galvanized steel conduit covered with a bonded 40 mil (minimum) thickness PVC jacket and coated inside with urethane.

2. Set screw or indentor type connectors shall not be used. Fittings for conduit installed in wet locations and underground shall provide a watertight joint. Fittings shall be threaded.

3. The PVC coated galvanized rigid steel (GRS) conduit must be UL Listed. RGS shall be hot-dip galvanized after fabrication, conforming to ANSI C80.1 and UL 6. The PVC coating must have been investigated by UL as providing the primary corrosion protection for the rigid metal conduit. Ferrous fittings for general service locations must be UL Listed with PVC as the primary corrosion protection. Hazardous location fittings, prior to PVC coating must be UL
listed. All PVC coated conduit, fittings, and accessories must be new, unused material. Applicable UL standards may include: UL 6 Standard for Safety, Rigid Metal Conduit, UL 514B Standard for Safety, Fittings for Conduit and Outlet Boxes.

4. The conduit shall be hot dip galvanized inside and out with hot galvanized threads.

5. A PVC sealing sleeve extending one pipe diameter or 2”, whichever is less, shall be formed at every female fitting opening, except unions. The inside sealing sleeve diameter shall be matched to the outside diameter of the conduit.

6. The PVC coating on the outside of conduit couplings shall be 40 mils in thickness and have a series of raised longitudinal ribs to protect the coating from tool damage during installation.

7. Form 8 condulets, ½” through 2” diameters, shall have a tongue-in-groove, V-Seal gasket to effectively seal against the elements. The design shall be equipped with a positive placement feature to ease and assure proper installation. Certified results confirming seal performance at 15 psig (positive) and 25” of mercury (vacuum) for 72 hours shall be available.

8. Form 8 condulets shall be supplied with plastic encapsulated stainless steel cover screws.

9. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings. This internal coating shall be a nominal 2-mil thickness. Conduit or fittings having pinholes or areas with thin or no coating shall be unacceptable.

10. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperatures above 30˚F (-1˚C).

11. All factory cut threads on conduit, elbows, nipples, and fittings shall be protected by application of a urethane coating.

12. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the PVC coated conduit. All U bolts will be supplied with plastic encapsulated nuts that cover the exposed portions of the threads.

13. Installation of the PVC coated conduit system shall be performed in accordance with the manufacturer’s installation manual. To assure correct installation, the installer shall be certified by the PVC coated conduit manufacturer before the installation can begin.

14. All PVC coated conduit, fittings, and accessories shall be supplied by the same manufacturer.

15. PVC coated conduit systems shall be Plasti-Bond, Perma-Cote, KorKap or approved equal.

PART 3 – EXECUTIONS

3.1 CONDUIT AND FITTINGS

A. Metallic conduit not installed under existing pavement, building foundation, encased in slab, or structure shall be factory coated with 40 mil minimum permanently bonded polyvinylchloride. Bond between metal and plastic shall be greater than tensile strength of plastic coating. All fittings shall be similarly protected. Metallic conduit installed under existing pavement or structure shall be factory coated PVC and with factory coated fittings.

B. Conduits shall be installed at the approximate location specified by the Engineer, who shall indicate specific locations and time for the construction of sections of the underground work, such
Section 26 05 33.13 | PVC Coated Galvanized Rigid Steel Conduit

as will best suit the general progress of the work. The Contractor shall arrange his work to meet these requirements. The type of conduit used shall not be mixed.

C. Horizontal and vertical bends of metallic conduit shall have a minimum radius of 12 times conduit inner diameter either factory made or field formed, with all ends threaded. Vertical bends, other than gradual sweeps, shall be made with metallic conduit.

D. Conduits entering pull boxes/manholes without stub-outs shall be installed through holes core drilled in pull box/manhole walls and terminated in bell ends. All holes/voids around the conduits shall be sealed with mortar consisting of Portland cement and sand after conduits are installed.

E. Empty conduit systems shall be furnished and installed as indicated on the Drawings and shall have pull wires installed. The pull wire shall be of plastic material, having not less than 200-pound tensile strength. Not less than 12” of slack shall be left at each end of the pull wire.

F. Each piece of conduit installed shall be free from blisters or other defects. Each piece installed shall be cut square, taper reamed, and a coat of sealing compound applied to threads. Threads on conduits shall be painted with a conducting compound prior to making up in a fitting. Conduit connections shall be made with standard coupling and the ends of the conduit shall butt tightly into the couplings. In exposed work only, where standard coupling cannot be used, only Erickson couplings are permitted, or as otherwise acceptable to the Engineer.

G. Conduit threaded in the field shall be of standard sizes and lengths.

H. All bends shall be made with standard factory conduit elbows or field bent elbows per NEC. Field bending of conduit shall be done using tools approved for the purpose. Heating of conduit to facilitate bending is prohibited. Field bends shall be not less than the same radius than a standard factory conduit elbow. Bends with kinks shall not be acceptable.

1. All conduits for fiber optic cable shall have a minimum bending radius as determined by the EIA/TIA Standards.

I. All conduit extending through the floor behind panels or into control centers or similar equipment shall extend a minimum of 6” above the floor elevations, where practicable, with no couplings at floor elevations.

J. Conduit shall be protected immediately after installation by installing flat non-corrosive metallic discs and steel bushings, designed for this purpose, at each end. Discs shall not be removed until it is necessary to clean the conduit and install the conductors. Before the conductors are installed, insulated bushings shall be installed at each end of the conduit.

K. Where “all-thread” nipples are used between fittings and electrical equipment, they shall be so installed that no threads are exposed.

L. All threaded ends of conduits shall be coated with an approved conducting compound as manufactured by Thomas & Betts, or equal prior to making up the joint.

M. Conduits installed within or underneath floor slabs, underground direct-buried or concrete encased conduits, and all conduits installed in areas subject to liquid inadvertently entering the conduit system shall be sealed or plugged at both ends in accordance with NEC Article 300-5(g). This requirement applies to both conduits containing conductors and “spare” conduits. Where practicable, the interior of the conduit shall be sealed as well as around the conductors by using
conduit sealing bushings: Type CSB as manufactured by O/Z Gedney, or approved equal. Where the conduit fill does not allow the use of these bushings, the conduits shall be tightly caulked or plugged.

N. Conduit passing through the walls and floors of buildings below grade shall be installed with appropriate watertight fittings to prevent the entrance of ground water around the periphery of the conduits. For vertical conduit penetrations through openings in concrete floors, the fittings shall be Type FSK Floor Seals as manufactured by OZ/Gedney. For conduit penetrations through openings in concrete walls, the fittings shall be Type WSK Thruwall seals as manufactured by OZ Gedney, or approved equal. Conduits shall be sloped away from the buildings toward splice boxes, hand holes and/or manholes to provide drainage away from the building wall.

O. Conduits passing through sleeves in interior walls and floors shall be tightly caulked with approved materials, fire rating shall not be compromised.

P. The use of 2 locknuts and bushing shall be required at all conduit terminations where hub type fittings are not required.

Q. Use proper installation tools approved for the purpose to assemble coated conduit systems to prevent damage to the covering and maintain the corrosion-resistant integrity of the conduit system. No damage to the covering is permitted. Use “touch-up” compounds to repair minor damage to the interior or exterior coatings. Painting shall be as specified in Painting and Coating requirements.

R. The Contractor shall furnish and install conduit entering or leaving NEC Article 500 hazardous areas with conduit seals. The Contractor shall also install conduit entering or leaving areas of buildings in which sodium hypochlorite is stored or distributed with conduit seals. The Contractor shall furnish and install conduit seals in other hazardous locations as required by the NEC.

3.2 INSTALLATION

A. All conduits shall be securely fastened in place during construction and progress of the work, and shall be plugged to prevent seepage of grout, water or dirt.

B. Conduits shall be of the size, material and type specified under Items of this contract.

C. All conduits installed without conductors shall be mandrelled. For cleaning the conduit, the mandrel shall have cups or brushes or combination of cups and brushes to adequately clean the conduit without damage. The cleaning mandrel shall be iron-shod for all conduits. A wood mandrel of dimensions specified above and with leather or rubber gaskets slightly larger than the inside diameter of the conduit shall be pulled through each conduit to prove each conduit free from dirt, obstructions.

D. All conduits installed without conductors shall be provided with 1/8” nylon line for pulling in future conductors or stronger pulling rope. Both ends of line shall be secured to prevent being pulled into conduit. Conduits which do not terminate in a pull box, base or other enclosure shall be plugged with removable, tapered plugs designed by the duct manufacturer or with conduit caps to prevent entry of dirt or moisture.

E. Metallic conduit installed under existing pavement maybe installed by a horizontal drilling technique utilizing the Bentonite Slurry Method or other approved technique. The horizontal auguring shall commence not less than 10 feet beyond pavement and shall be continued to a point...
not less than 10 feet beyond the pavement. When such operations require the closing of a runway, the work shall continue on a 24-hour-a-day basis until all work is completed and runway is ready for use.

F. Top of conduit shall be a minimum of 24" below finished grade. Pockets or traps where moisture may accumulate shall be avoided.

G. Runs of nonmetallic duct buried in earth longer than 50 feet shall be installed with expansion fittings at each end.

H. All field bends in rigid metallic conduits shall be made in approved manner and shall be of the proper radius.

I. The conduits which penetrate through the wall shall be sealed around the conduit.

J. The conduits terminating in the box shall be fastened with a ground bushing.

END OF SECTION 26 05 33.13
SECTION 26 05 43 – UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings, documents, and general provisions of the Contract, including but not limited to General Conditions, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks.
   2. Hand holes and boxes.

1.3 DEFINITION

A. RNC: Rigid nonmetallic conduit.

1.4 REFERENCES

A. Comply with the latest versions of the following Standards:
   1. American Society for Testing and Materials (ASTM)
   2. American National Standards Institute (ANSI)
   3. National Fire Protection Association (NFPA)
   4. National Electrical Manufacturers Association (NEMA)
   5. Society of Cable Telecommunications Engineers (SCTE)
   6. International Organization for standardization (ISO)
   7. National Institute of Standards and Technology (NIST)
   8. American Association of state Highway and Transportation Officials (AASHTO)

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Duct-bank materials, including separators and miscellaneous components.
   2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
   3. Accessories for hand holes, boxes, and other utility structures.
   4. Warning tape.

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

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

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

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

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

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.

E. Product Certificates: For concrete and steel used in precast concrete hand holes, as required by ASTM C 858.

F. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Comply with ANSI C2.
B. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.8 COORDINATION

A. Coordinate layout and installation of ducts, hand holes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.
B. Coordinate elevations of ducts and duct-bank entrances into hand holes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to hand holes, and as approved by Architect.

PART 2 – PRODUCTS

2.1 CONDUIT

A. RNC: NEMA TC 2, Type EPC-40-PVC to be used in concrete encased duct bank.

B. PVC coated rigid galvanized steel to be used for direct buried in earth type of installation.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Available Manufacturers: Subject to compliance with requirements;
   1. ARNCO Corp.
   2. Beck Manufacturing.
   3. Cantex, Inc.
   6. ElecSys, Inc.
   7. Electri-Flex Company.
   8. IPEX Inc.
   9. Lamson & Sessions; Carlon Electrical Products.
   10. Manhattan/CDT; a division of Cable Design Technologies.
   11. Spiraduct/AFC Cable Systems, Inc.
   12. Or approved equal.

B. Duct Accessories:
   1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
   2. Warning Tape: Underground-line warning tape specified in Division 26 Section “Identification for Electrical Systems.”

2.3 PRECAST CONCRETE HANDHOLES AND BOXES

A. Available Manufacturers: Subject to compliance with requirements;
   1. Carder Concrete Products.
   2. Christy Concrete Products.
   3. Elmhurst-Chicago Stone Co.
5. Riverton Concrete Products; a division of Cretex Companies, Inc.
6. Utility Concrete Products, LLC.
8. Wausau Tile, Inc.
9. Or approved equal.

B. Comply with ASTM C 858 for design and manufacturing processes.

C. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of hand hole or box.

1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
   a. Cover Hinges: Concealed, with hold-open ratchet assembly.
   b. Cover Handle: Recessed.
4. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.
   a. Cover Hinges: Concealed, with hold-open ratchet assembly.
   b. Cover Handle: Recessed.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 1/2.
6. Cover Legend: Molded lettering, “ELECTRIC.” or “TELEPHONE.”
7. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
8. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
   a. Extension shall provide increased depth of 12”.
   b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.
9. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12” vertically and horizontally to accommodate alignment variations.
   a. Windows shall be located no less than 6” from interior surfaces of walls, floors, or frames and covers of hand holes, but close enough to corners to facilitate racking of cables on walls.
   b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
   c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
10. Duct Entrances in Hand hole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
   a. Type and size shall match fittings to duct or conduit to be terminated.
   b. Fittings shall align with elevations of approaching ducts and be located near interior corners of hand holes to facilitate racking of cable.

11. Hand holes 12" wide x 24" long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.4 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Description: Comply with SCTE 77.

2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 1/2.
5. Cover Legend: Molded lettering, “ELECTRIC.” or “TELEPHONE.”
6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
8. Hand holes 12" wide x 24" long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

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

1. Available Manufacturers:
   a. Armorcast Products Company.
   b. Carson Industries LLC.
   c. CDR Systems Corporation.
   d. NewBasis.
   e. Or approved equal.

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

1. Available Manufacturers:
   a. Armorcast Products Company.
   b. Carson Industries LLC.
   c. Christy Concrete Products.
   d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.
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e. Or approved equal.

D. Fiberglass Hand holes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.
   1. Available Manufacturers:
      a. Carson Industries LLC.
      b. Christy Concrete Products.
      c. Nordic Fiberglass, Inc.
      d. Or approved equal.

E. High-Density Plastic Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be polymer concrete.
   1. Available Manufacturers:
      a. Carson Industries LLC.
      b. Nordic Fiberglass, Inc.
      c. PenCell Plastics.
      d. Or approved equal.

2.5 UTILITY STRUCTURE ACCESSORIES

A. Available Manufacturers:
   1. Bilco Company (The).
   2. Campbell Foundry Company.
   3. Carder Concrete Products.
   4. Christy Concrete Products.
   5. East Jordan Iron Works, Inc.
   7. McKinley Iron Works, Inc.
   13. Riverton Concrete Products; a division of Cretex Companies, Inc.
   14. Strongwell Corporation; Lenoir City Division.
   15. Underground Devices, Inc.
   16. Utility Concrete Products, LLC.
   17. Utility Vault Co.
   18. Wausau Tile, Inc.
   19. Or approved equal.

B. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2” diameter eye, and 1” x 4” bolt.
   1. Working Load Embedded in 6”, 4000-psi Concrete: 13,000-lbf minimum tension.

C. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1 ¼” diameter eye, rated 2500-lbf minimum tension.
D. Pulling-In and Lifting Irons in Concrete Floors: 7/8” diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
   1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.

E. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; ½” ID x 2 ¾” deep, flared to 1 ¼” minimum at base.
   1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

F. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with ½” bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

G. Cable Rack Assembly: Steel, hot-rolled galvanized, except insulators.
   1. Stanchions: T-section or channel; 2 ¼” nominal size; punched with 14 holes on 1 ½” centers for cable-arm attachment.
   2. Arms: 1 ½” wide, lengths ranging from 3” with 450-lb minimum capacity to 18” with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.

H. Duct-Sealing Compound: Non-hardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 ºF. Capable of withstanding temperature of 300 ºF without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

2.6 SOURCE QUALITY CONTROL

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

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

PART 3 – EXECUTION

3.1 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Cables over 600 V: PVC Coated GRS or RNC, NEMA Type, in concrete-encased duct bank with reinforcement rebar, unless otherwise indicated.
B. Ducts for Electrical Feeders 600 V and Less: PVC Coated GRS or RNC, NEMA Type, in concrete-encased duct bank with reinforcement rebar, unless otherwise indicated.

C. Ducts for Electrical Branch Circuits: PVC Coated GRS or RNC, NEMA Type, in concrete-encased duct bank with reinforcement rebar, unless otherwise indicated.

D. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, Type EPC-40 PVC, direct buried in earth, unless otherwise indicated.

3.2 UNDERGROUND ENCLOSURE APPLICATION

A. Hand holes and Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:
   1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
   2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Non-deliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
   4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.

3.3 EARTHWORK

A. Excavation and Backfill: Comply with “Excavating, Backfilling and Compacting.” Requirements but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with “Landscaping” specifications.

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to “Cutting and Patching” requirements.

3.4 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and hand holes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius 5 times the conduit diameter or 48” whichever is greater, both horizontally and vertically, at other locations, unless otherwise indicated.

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer’s written instructions. Stagger couplings so those of adjacent ducts do not lie in
same plane.

D. Duct Entrances to Manholes and Concrete and Polymer Concrete Hand holes: Use end bells, spaced approximately 10" o.c. for 5" ducts, and vary proportionately for other duct sizes.
   1. Begin change from regular spacing to end-bell spacing 10’ from the end bell without reducing duct line slope and without forming a trap in the line.
   2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to hand hole.
   3. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Building Wall Penetrations: Outside the building footprint the underground conduit pathway to the nearest utility vault and/or pull box shall either be with PVC coated rigid steel conduit or concrete reinforced duct bank. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 26 05 44 “Sleeves and Sleeve Seals for Electrical Raceways and Cabling.”

F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

G. Pulling Cord: Install 100-lbf-test nylon cord in ducts, including spares.

H. Concrete-Encased Ducts: Support ducts on duct separators.
   1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20’ of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6’ between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
   2. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
      a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer’s written recommendations, or use other specific measures to prevent expansion-contraction damage.
      b. If more than one pour is necessary, terminate each pour in a vertical plane and install ¾” reinforcing rod dowels extending 18” into concrete on both sides of joint near corners of envelope between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
      c. Five pounds red lead oxide shall be added per cubic yard of concrete for all medium voltage duct banks.
   3. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
4. **Forms:** Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.

5. **Minimum Space between Ducts:** 3” between ducts and exterior envelope wall, 2” between ducts for like services. Power and signal ducts sharing the same trench or excavation shall be separated longitudinally by ¼” thick plywood along the entire length of duct. Distance from raceways to plywood separator shall be 4”.

6. **Depth:** Install top of duct bank at least 24” below finished grade, unless otherwise indicated. Duct Banks shall be laid so as to slope towards manholes with a drop of at least 3” per 100’ unless otherwise noted on drawings.

7. **Stub-Ups:** Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.

8. **Warning Tape:** Provide 6” wide red polyethylene with wording “Caution Electrical Lines Below” warning tape. Bury warning tape approximately 12” above all concrete-encased ducts and duct banks. Align tape parallel to and within 3” of the centerline of duct bank. Provide an additional warning tape for each 12” increment of duct-bank width over a nominal 18”. Space additional tapes 12” apart, horizontally.

9. **Reinforced duct bank shall constitute not less than 4-#4 rebars tied together with #4 rebars spaced a maximum of 30” on center.**

**I. Direct-Buried Duct Banks:**

1. **Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.**

2. **Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20’ of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6” between tiers.**

3. **Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified for pipes less than 6” in nominal diameter.**

4. **Install backfill as specified by “Excavating, Backfilling and Compacting” requirements.**

5. **After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4” over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in “Excavating, Backfilling and Compacting” requirements.**

6. **Install ducts with a minimum of 3” between ducts for like services. Power and signal ducts sharing the same trench or excavation shall be separated longitudinally by 1/4” thick plywood along entire length of duct. Distance from raceways to plywood separator shall be 6”.**

7. **Depth:** Install top of duct bank at least 36” below finished grade, unless otherwise indicated.

8. **Set elevation of bottom of duct bank below the frost line.**
9. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3” of concrete.
   b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60” from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

10. Warning Tape: Provide 6” wide red polyethylene with wording “Caution Electrical Lines Below” warning tape. Bury warning tape approximately 12” above all concrete-encased ducts and duct banks. Align tape parallel to and within 3” of the centerline of duct bank. Provide an additional warning tape for each 12” increment of duct-bank width over a nominal 18”. Space additional tapes 12” apart, horizontally.

J. Underground raceway within Airport roadways and assessments shall be run parallel or perpendicular to road centerline or lease lines.

3.5 INSTALLATION OF CONCRETE HANDHOLES, AND BOXES

A. Precast Concrete Hand hole Installation:
   1. Comply with ASTM C 891, unless otherwise indicated.
   2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
   3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1” sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:
   1. Hand hole Covers: In paved areas and traffic ways, set surface flush with finished grade. Set covers of other hand holes one inch (1”) above finished grade.
   2. Where indicated, cast hand hole cover frame integrally with hand hole structure.

C. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

D. Field-Installed Bolting Anchors in Concrete Hand holes: Do not drill deeper than 2” for hand holes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.6 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install hand holes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from ½” sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and traffic ways, set so cover surface will be flush with finished grade.
Set covers of other hand holes one inch (1") above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

E. Field-cut openings for ducts and conduits according to enclosure manufacturer’s written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

F. For enclosures installed in asphalt paving and subject to occasional, non-deliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screwed to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi, 28-day strength, complying with “Cast-in-Place Concrete” requirements, with a troweled finish.

2. Dimensions: 10" wide x 12" deep.

3.7 GROUNDING

A. Ground underground ducts and utility structures according to Section 26 05 26 “Grounding and Bonding for Electrical Systems.”

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.

2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80% fill of duct. If obstructions are indicated, remove obstructions and retest.

3. Test hand hole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26 “Grounding and Bonding for Electrical Systems.”

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.9 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 26 05 43
SECTION 26 05 44 – SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
5. Silicone sealants.

1.3 REFERENCES

A. Comply with the latest versions of the following standards:

1. American Society for Testing and Materials (ASTM)
2. National Electrical Manufacturers Association (NEMA)
3. National Electrical Code (NEC)
4. National Electrical Contractors Association (NECA) Standards

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit EQ 4: For sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services “Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers.”

PART 2 – PRODUCTS

2.1 SLEEVES
A. Wall Sleeves:

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Sleeves for Rectangular Openings:
   2. Minimum Metal Thickness:
      a. For sleeve cross-section rectangle perimeter less than 50" and with no side larger than 16", thickness shall be 0.052".
      b. For sleeve cross-section rectangle perimeter 50" or more and one or more sides larger than 16", thickness shall be 0.138".

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Advance Products & Systems, Inc.
   b. CALPICO, Inc.
   c. Metraflex Company (The).
   d. Pipeline Seal and Insulator, Inc.
   e. Proco Products, Inc.

2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

3. Pressure Plates: Carbon steel.

4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, water stop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber water stop collar with center opening to match piping OD.

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

A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.


C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

2. Sealant shall have VOC content compliant with LEED requirements or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' “Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers.”

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

PART 3 – EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

NOTE: Where sleeves are required, their purpose and intended use shall be specifically identified.

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

   a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in “Joint Sealants.”

   b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

3. Size pipe sleeves to provide \( \frac{1}{4} \)" annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.

4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.

5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2" above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
   1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
   2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1" annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1" annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

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

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water stop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.
SECTION 26 05 48 – VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.1 GENERAL

A. General: Provide Vibration Isolators and Seismic Restraints in accordance with the contract documents.

B. The requirements of this Section govern all sections of Division 26.

1.2 RELATED DOCUMENTS

A. Drawings, documents, and general provisions of the Contract, including but not limited to General Conditions, apply to this Section.

1.3 SUMMARY

A. This Section includes the following:
   1. Isolation pads.
   2. Channel support systems.
   3. Restraint cables.
   4. Hanger rod stiffeners.
   5. Anchorage bushings and washers.

B. Related Sections include the following:
   1. Section 26 05 29 “Hangers and Supports for Electrical Systems” for commonly used electrical supports and installation requirements.

1.4 REFERENCES

A. International Building Code (IBC)

B. ICC-Evaluation Service (ICC-ES)

C. Office of Statewide Health Planning and Development for the State of California (OSHPD)

D. California Building Code (CBC)

E. American Welding Society (AWS)

F. International Building Code (IBC)

G. Nationally Recognized Testing Laboratory (NRTL)
1.5 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
   1. Site Class as Defined in the 2001 CBC.
   2. Assigned Seismic Use Group or Building Category as Defined per the 2001 CBC.
      a. Component Importance Factor: 1.0 for normal systems and 1 1/2 for systems required for life safety.
      b. See 2001 CBC Table 16-0 for Horizontal Force Factors.

B. Wind Loads – Structural Design Basis:
   1. Importance Factor – See Structural Design Basis.

C. Seismic Design – Structural Design Basis:
   1. Importance Factor – See Structural Design Basis.

D. Live Loads – Structural Design Basis.
   1. Importance Factor – See Structural Design Basis.

1.6 SUBMITTALS

A. Product Data: For the following:
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
      b. Annotate to indicate application of each product submitted and compliance with requirements. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For seismic-restraint details 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. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
      a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.
   2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
3. Field-fabricated supports.

4. Seismic-Restraint Details:
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events.
   c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

D. Shop drawing submittals shall include, but not be limited to, the following:
   1. A complete listing of the proposed type of isolators and seismic restraints for each specified application, including size and deflection information.
   2. Selection calculations for all isolators and restraints with weight, size and deflection note at each support point.
   3. Cut sheets for all bases, isolators and seismic restraints.
   4. A clearly outlined procedure for installing and adjusting vibration isolators and seismic restraints.
   5. Additional information as required by General Electrical requirements.

E. Welding certificates.

F. Qualification Data: For testing agency.

G. Field quality-control test reports.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver vibration isolators and seismic restraints in factory-fabricated water-resistant wrapping.

B. Handle all material carefully to avoid damage to components, enclosures and finishes.

C. Store all material in clean, dry space and protect from the weather.

1.8 QUALITY ASSURANCE

A. General: Obtain all vibration isolation materials from a single manufacturer, as much as possible.

B. Supervision: Vibration Isolation and Seismic Restraint manufacturer and the engineer certifying the
calculations shall provide technical supervision of the installation, and provide a written certificate to verify compliance of the field installation.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

D. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

E. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, “Structural Welding Code - Steel.”

F. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

G. Comply with NFPA 70.

PART 2 – PRODUCTS

2.1 VIBRATION ISOLATORS

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

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
4. Isolation Technology, Inc.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
10. Or approved equal.

B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. All spring isolators shall be completely stable in operation and shall be designed for not less than 50% reserve deflection beyond actual operating conditions. Spring isolators shall be horizontally stable with spring diameter not less than 0.8 times the operating height and horizontal to
vertical spring constant ratio between 0.90 and 1.10. Dual spring models with inner and outer springs and multiple spring models shall not be acceptable.

D. All isolator components shall be of neoprene or high quality synthetic rubber with antioxidant additives and shall be sized for a maximum load of 60 psi and a rating of 40 durometers.

E. All vibration isolators and bases furnished by the Contractor shall be designed for and treated for resistance to corrosion. Steel components shall be cleaned and painted with industrial grade enamel. All nuts, bolts, and washers shall be zinc-electroplated. Structural steel bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate or metal etching primer. A finish coat of industrial grade enamel shall be applied over the primer.

F. All isolators or Emergency generators shall have cadmium coated springs dipped in neoprene, cadmium plated hardware and hot-dipped galvanized holders.

G. Isolators for equipment installed outdoors shall be designed to provide adequate restraint due to normal wind conditions and to withstand wind loads of 50 pounds/square foot applied to any exposed surface of the isolated equipment. Where isolators do not meet this requirement, stainless steel tie down cables with 1/4” slack shall be provided.

H. All isolators supporting a given piece of equipment shall be selected for approximately equal spring deflection, ±10%.

I. Provide leveling devices and install springs such that ends of springs remain parallel.

J. For Seismic Restraint criteria of the vibration isolators, see Paragraph "SEISMIC RESTRAINTS."

2.2 SEISMIC-RESTRAINT DEVICES

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

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti Inc.
5. Loos & Co.; Seismic Earthquake Division.
7. TOLCO Incorporated; a brand of NIBCO INC.
8. Unistrut; Tyco International, Ltd.
9. ISAT Seismic Bracing, a Division of Tomarco Contractor Specialties.
10. Or approved equal.

B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be
subjected.

C. Provide seismic restraints, supports and anchorage for all Generators, Load Centers, switching stations, switchboards, conduits, bus ducts, lighting fixtures, junction boxes and equipment either hung or mounted otherwise, per the requirements of California Building Code (CBC) Title-24, with amendments using the Hospital and Essential Building Seismic Design Criteria 1991 Edition thru October 1994 seismic with an importance factor of 1 1/2. The criteria shall be applied appropriately to both rigidly and flexibly supported equipment and conduits. Preapproved OSHPD seismic restraints or qualified to be approved by OSHPD shall be acceptable.

D. Contractor shall provide flexible devices for all conduits and bus ducts which cross building separation space (building seismic joints) whether shown on plan or not. Such devices shall be designed and detailed to accommodate displacements calculated on the basis noted in Title 24, CBC Section 2836 or as indicated on the structural drawings and calculations. Contractor shall submit the required details on the plans along with the substantiating calculations.

E. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

F. Building structural steel shall not be cut or modified without the written approval of the structural engineer of record. Patch and repair fireproofing at the point of connection to the structure.

1. General Contractor shall coordinate installation and location of seismic restraints for anchorage of all conduit bus duct and equipment including related contract work, such as, baggage handling system supports.

2. Where coordination conflicts do not allow the use of pre-approved seismic restraint details, provide additional details and calculations as necessary to meet CBC design criteria.

3. Modifications to pre-approved details are not acceptable. Contractor shall be responsible for any additional costs for the review of all detail substitutions.

G. Restraint Cables: ASTM A 603 galvanized-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service.

H. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Do not weld stiffeners to rods.

I. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

J. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

K. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

L. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength...
required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter. ACI 318 Standard Minimum anchor embedment per manufacturer supplied ICC report.

M. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488. ACI318 Standard Minimum anchor embedment per manufacturer-supplied ICC report.

2.3 ISOLATOR TYPES

A. General: Isolator types shall be one or more of the following types as listed below and as scheduled on the drawings. Model numbers of Mason products are included for identification. Products of other specified manufacturers are acceptable provided they comply with all of the requirements of the specifications.

B. Snubbers: All directional seismic snubber with steel and all directional neoprene bushing, snubber bolt and washer. OSHPD preapproved acceptable is approved. Provide restraining angle after equipment installation to assure design clearances.

C. Slack Cable: Seismic cable and brace anchor assembly Model SCB. Galvanized aircraft cable 7 x 19 strand core, formed steel cable base anchors. Select as required for loads and install per manufacturer's recommendations.

2.4 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. General: Seismic Restraints shall be installed in accordance with the manufacturer's instructions and Title 24, CBC criteria. (See Seismic Restraint Criteria.)

B. Equipment and Hanger Restraints:
   1. Install restrained isolators on electrical equipment.
   2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 1/8”.
   3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

C. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

E. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

F. Provide calculations, details and drawings for conduits and bus ducts showing location of supports, anchorage, guides, expansion joints/loops, and flexible connections at seismic joints. The calculations shall clearly indicate the location, direction and load forces transferred to the structure. The calculations shall take into account the operating weight thermal

G. Expansion/contraction forces and seismic forces. The calculations shall indicate method of attachment to the structure, size of anchor bolts, depth of embedment, welding size, etc.

H. The anchorage details and calculations must be submitted sufficiently in advance of the desired date of approval to provide time for the initial review by the General Contractor/Architects, structural engineer of record and electrical engineer of record, and at least on cycle of response and back check.

I. Seismic restraints must be installed and adjusted so that electrical equipment, transformers and vibration isolation is not degraded by utilization of restraints.

J. Contractor shall install supports, bracing and anchoring per the approved shop drawings. After the completion of the installation and adjustments, the contractor shall certify that seismic restraints have been installed to meet the requirements of Code, specifications, the seismic restraints criteria and approved shop drawings, signed by a structural/civil engineer registered in the State of California.

K. Criteria:
   1. Seismic Force Criteria: Per CBC with both lateral and uplift occurring simultaneously.
      a. Rigidly mounted conduit, bus duct and equipment per CBC.
      b. Flexibly mounted conduit and equipment per CBC.
   2. Restrain major equipment per CBC. Install all equipment per manufacturer’s spec.

L. Attachments to Structure: As specified.

M. Flexibly Supported Equipment, Piping and Ducts:
   1. General: Restrain as indicated or as required. Provide and locate restraints to allow normal operation of system without transmitting vibrations to building structure. Normal operation includes static condition, start-up, normal running and shut-down. Allow maximum of 1/4” between restraint and restrained device.
   2. Base Mounted Equipment: Restraints to be separate from vibration isolator unless otherwise indicated. Minimum four restraints for each piece of equipment.

3.4 VIBRATION ISOLATOR INSTALLATION

A. General: Except as otherwise indicated comply with manufacturer’s instructions for the installation and load application of vibration isolation materials and units. Adjust to ensure that units do not exceed rated operating deflections, do not bottom out under loading, and are not short circuited by seismic restraints, other contacts or bearing points. Remove space blocks and similar devices (if any) intended for temporary protection against overloading during installation.
B. Secure Attachment: Anchor and attach units to substrate and equipment for secure operation, to prevent displacement by normal forces. Submit calculations for anchor and attachments for approval.

C. Adjustment: Adjust leveling devices to distribute loading uniformly onto Shim units where leveling devices cannot be used to distribute loading properly.

D. Base Frames: Install inertia base frames on isolator units so a 2” (minimum) clearance below base will result when frame is filled with concrete and supported equipment has been installed and loaded for operation.

E. Welding: Weld riser isolator units in place to prevent displacement from loading and operations.

3.5 EQUAL LOADING

A. General: All equipment installed on vibration isolation mountings shall be level after load is applied. Further, vibration isolation mountings shall be selected and installed to compensate for unequal loading. Spring isolators with coils touching during equipment start up or operation will not be acceptable.

3.6 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wire ways, cable trays, and bus ways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements. Such devices shall be designed and detailed to accommodate displacements calculated on the basis noted in Title 24, CBC Section 2836 or as indicated on the structural drawings and calculations. Contractor shall submit the required details on the plans along with the substantiating calculations.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Perform tests and inspections.

C. Tests and Inspections:
   1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least 7 days’ advance notice.
   4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
   5. Test per special inspection requirements listed in the manufacturer ICC reports.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.8 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 26 05 48
SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Nameplates, Labels, and Identification for:
      a. Raceways.
      b. Power and control cables.
      c. Conductors.
      d. Warning labels and signs.
      e. Instruction signs.
      f. Equipment.
      g. Miscellaneous products.
   2. Wire markers.
   3. Conduit markers.
   4. Stencils.
   5. Underground Warning Tape.

1.2 REFERENCES

A. Perform Work in accordance with all applicable codes and standards.

B. American National Standards Institute (ANSI)
   3. Z535.4 – American National Standard for Product Safety Signs and Labels

C. National Fire Protection Association (NFPA):

D. Code of Federal Regulation (CFR) 29:
   1. 1910.144 – Safety color code for marking physical hazards.
   2. 1910.145. – Specifications for accident prevention signs and tags

E. Underwriters Laboratories (UL)
1. 969 – Marking and Labeling Systems

F. American Standards for Testing and Materials (ASTM)

1.3 SUBMITTALS

A. As per Submittal procedures.

B. Product Data:
   1. Submit manufacturer’s catalog literature for each product required.
   2. Submit electrical identification schedule including list of wording, symbols, letter size, color coding, tag number, location, and function.

C. Manufacturer’s Installation Instructions: Indicate installation instructions, special procedures, and installation.

1.4 CLOSEOUT SUBMITTALS

A. As per Contract Closeout Requirements for submittals.

B. Project Record Documents: Record actual locations of tagged devices; include tag numbers.

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

D. Identification Schedule: An index of nomenclature of electrical equipment and system components and identification signs and labels.

1.5 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in products specified in this section with minimum 5 years’ experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. As per requirements for transporting, handling, storing, and protecting products.

B. Accept identification products on site in original containers. Inspect for damage.

C. Accept materials on site in original factory packaging, labeled with manufacturer’s identification, including product density and thickness.

D. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.8 ENVIRONMENTAL REQUIREMENTS

A. As per requirements for environmental conditions affecting products on site.
B. Install labels or nameplates only when ambient temperature and humidity conditions for adhesive are within range recommended by manufacturer.

1.9 EXTRA MATERIALS

A. As per Contract Closeout Requirements for extra materials.

1.10 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer’s wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 – PRODUCTS

2.1 NAMEPLATES

A. All details on nameplates, labels, and wire markers shall be submitted in advance as a shop drawing for approval.

B. Furnish and install materials in accordance with this section of the specification.

C. Product Description: Laminated three-layer plastic with engraved letters.

D. Letter Size: To be included in submittal.

E. Minimum nameplate thickness: 1/8”.

2.2 LABELS

A. Labels: Embossed adhesive tape, with orange background.

B. Furnish and install materials in accordance with approved submittal.

NOTE: Hand written labeling on conduits are not acceptable.

2.3 WIRE MARKERS

A. Furnish and install materials in accordance with approved submittal.

B. Description: Cloth tape or tubing type wire markers.
C. Legend:
   1. Power and Lighting Circuits: Branch circuit or feeder number as indicated on Drawings.
   2. Control Circuits: Control wire number as indicated on schematic and interconnection diagrams.

2.4 CONDUIT AND RACEWAY MARKERS

A. Furnish and install materials in accordance with approved submittal.

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

C. Color:
   1. Colors for Raceways Carrying Circuits at 600 V or Less:
      a. Black letters on an orange field.

D. Legend: indicate voltage.
   1. Medium Voltage System: “12KV HIGH VOLTAGE.”
   2. 480 Volt System: “480 VOLTS.”
   3. 208 Volt System: “208 VOLTS.”
   4. 120 Volt System: “120 VOLTS.”
   5. Emergency System in addition to system voltage: “EMERGENCY SERVICE.”
   6. Low Voltage Control System: “LOW VOLTAGE”.
   10. Fiber Optic System: “FIBER.”
   15. Supervisory Control and Data Acquisition System: “SCADA.”

E. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

F. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pre-tensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.5 METAL-CLAD CABLE IDENTIFICATION MATERIALS

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

B. Colors for Raceways Carrying Circuits at 600 V and Less:
1. Black letters on an orange field.
2. Legend: Indicate voltage.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.6 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

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

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Snap-Around Labels: Slit, pre-tensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.7 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2" wide.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Snap-Around Labels: Slit, pre-tensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.8 FLOOR MARKING TAPE

A. 2"-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.9 UNDERGROUND-LINE WARNING TAPE

A. Tape:
1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.

B. Color and Printing:
1. Comply with ANSI Z535.1 through ANSI Z 535.5.
2. Inscriptions for Red-Colored Tape: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS...
CABLE, OPTICAL FIBER CABLE.

2.10 WARNING LABEL AND SIGNS


B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Warning label and sign shall include, but are not limited to, the following legends:
   1. Multiple Power Source Warning: “DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES.”
   2. Workspace Clearance Warning: “WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES.”

2.11 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16” thick for signs up to 20 sq. inches and 1/8” thick for larger sizes.
   1. Engraved legend with black letters on white face.
   2. Punched or drilled for mechanical fasteners.
   3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8”.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8”. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.12 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8”.

B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8”. Overlay shall provide a weatherproof and UV-resistant seal for label.

C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8”.

D. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8”.

E. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be one inch (1”).
### 2.13 CABLE TIES

**A. General-Purpose Cable Ties:** Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: \( \frac{1}{4}'' \)
2. Tensile Strength at 73 °F, According to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 °F.

**B. Plenum-Rated Cable Ties:** Self-extinguishing, UV stabilized, one piece, self-locking.

1. Minimum Width: \( \frac{3}{16}'' \)
2. Tensile Strength at 73 °F, According to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 °F.
5. Color: Black

### 2.14 MISCELLANEOUS IDENTIFICATION PRODUCTS

**A. Paint:** Comply with requirements in painting sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

**B. Fasteners for Labels and Signs:** Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

### PART 3 – EXECUTION

#### 3.1 PREPARATION

**A.** Degrease and clean surfaces to receive adhesive for identification materials.

**B.** Prepare surfaces in accordance with requirements for stencil painting.

**C.** Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification devices.

#### 3.2 EXISTING WORK

**A.** Install identification on existing equipment to remain in accordance with this section.

**B.** Install identification on unmarked existing equipment if necessary.

**C.** Apply identification devices to surfaces that require finish after completing finish work.

**D.** Replace lost nameplates, labels or markers.
3.3 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Install identifying devices after completion of painting.

C. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

D. Nameplate Installation:
   1. Install nameplate parallel to equipment lines.
   2. Install nameplate for each electrical distribution and control equipment enclosure with corrosive-resistant mechanical fasteners, or adhesive.
   3. Install nameplates for each control panel and major control components located outside panel with corrosive-resistant mechanical fasteners, or adhesive.
   4. Secure nameplate to equipment front using screws, rivets, or adhesive.
   5. Secure nameplate to inside surface of door on recessed panel board in finished locations.
   6. Install nameplates for the following:
      a. Switchboards.
      b. Panel boards.
      c. Transformers.
      d. Service Disconnects.

E. Label Installation:
   1. Install label parallel to equipment lines.
   2. Install label for identification of individual control device stations, and
   3. Install labels for permanent adhesion and seal with clear lacquer.

F. Wire Marker Installation:
   1. Install wire marker for each conductor at panel board gutters, pull boxes, outlet and junction boxes, and each load connection.
   2. Mark data cabling at each end. Install additional marking at accessible locations along the cable run.
   3. Install labels at data outlets identifying patch panel and port designation.

G. Conduit Marker Installation
   1. Install conduit marker for each conduit raceway longer than 10 feet.
   2. Conduit Marker Spacing: every 20 feet.

H. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum
intervals in straight runs, and at 25-foot maximum intervals in congested areas.

I. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. In Spaces Handling Environmental Air: Plenum rated.

J. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8” below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16” overall.

K. Painted Identification: Comply with requirements in painting sections for surface preparation and paint application.

L. Install Work in accordance with contract documents.

3.4 IDENTIFICATION SCHEDULE

A. Concealed Raceways, Duct Banks, more than 600 V, within Buildings: Tape and stencil 4”-wide black stripes on 10” centers over orange background that extends full length of raceway or duct and is 12” wide. Stencil legend “DANGER CONCEALED HIGH VOLTAGE WIRING” with 3” high black letters on 20” centers. Stop stripes at legends. Apply to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12” of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts.
4. Exposed in the building, or concealed above suspended ceilings.

B. Identify with self-adhesive vinyl tape applied in bands. Install labels at 30’ maximum intervals.

C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, and hand holes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.

   a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.

   b. Colors for 208/120-V Circuits:
      1) Phase A: Black.
      2) Phase B: Red.
      3) Phase C: Blue.

   c. Colors for 480/277-V Circuits:
      1) Phase A: Brown.
      2) Phase B: Orange.
      3) Phase C: Yellow.

   d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6” from terminal points and in boxes where splices or taps are made. Apply
last 2 turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

D. Power-Circuit Conductor Identification, more than 600 V: For conductors in vaults, pull and junction boxes, and hand holes, use nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation.

   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

F. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
   1. Limit use of underground-line warning tape to direct-buried cables.
   2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

G. Working clearance shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated.

H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.
   2. Identify system voltage with black letters on an orange background.
   3. Apply to exterior of door, cover, or other access.
   4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
      a. Controls with external control power connections.

I. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

J. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
   1. Labeling Instructions:
      a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise
indicated, provide a single line of text with ½” high letters on 1 ½” high label; where 2 lines of text are required, use labels 2” high.

b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.

c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

2. Equipment to be Labeled:

a. Panel boards: Typewritten directory of circuits in the location provided by panel board manufacturer. Panel board identification shall be engraved, laminated acrylic or melamine label.

b. Enclosures and electrical cabinets.

c. Access doors and panels for concealed electrical items.

d. Switchboards.

e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panel boards or equipment supplied by the secondary.

f. Enclosed switches.

g. Enclosed circuit breakers.

h. Enclosed controllers.

i. Variable-speed controllers.

j. Push-button stations.

k. Contactors.

l. Remote-controlled switches, dimmer modules, and control devices.

m. Monitoring and control equipment.

END OF SECTION 26 05 53
APPENDIX A – MASTER LIST OF MANUFACTURERS

This section provides the Master List of Manufacturers approved for Medium Voltage and Electrical Equipment accepted by SFO organized by section and subsection. Contractors are responsible for any extra cost incurred when evaluating products by manufacturers that are not listed are approved equals.

26 05 13 - MEDIUM VOLTAGE CABLES

CABLES
1. General Cable
2. Okonite Company
3. Prysmian
   (No known approved equals)

TERMINATION KITS
1. Cooper Industries
2. Elastimold
3. Prysmian
4. Raychem
5. Or approved equal.

12 KV CABLE WRAPPING IN MANHOLES
1. 3-M Scotch Brand No. 27 Tape (for binding)
2. Irvington Brand No. 7700, 3”-wide arc-proofing tape
3. Or approved equal.

DEADBREAK ELBOWS
1. Cooper Industries
2. Elastimold.
3. Prysmian
4. Or approved equal.

BUSHING WELL PLUGS
1. Cooper Industries
2. Elastimold.
3. Or approved equal.

PROTECTIVE CAP
1. Cooper Industries
2. Elastimold.
3. Or approved equal.

ELBOW GROUNDING KIT
1. Elastimold.
2. RTE Corporation.
3. Or approved equal.

DEADBREAK MODULE

1. Cooper Industries
2. Elastimold.
3. Or approved equal.

CABLE SPLICING AND TERMINATING PRODUCTS AND ACCESSORIES

1. 3M; Electrical Products Division.
2. Raychem Corp.; Telephone Energy and Industrial Division; Tyco International Ltd.
3. Thomas & Betts Corporation.
4. Thomas & Betts Corporation/Elastimold.
5. Or approved equal.

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

CONDUCTORS AND CABLES

1. American Insulated Wire Corp; A Leviton Company.
2. General Cable Corporation.
5. Or approved equal.

SPLICES

1. 3M; Electrical Products Division.
2. AFC Cable Systems, Inc.
4. O-Z/Gedney; EGS Electrical Group LLC.
5. Tyco Electronics Corp.
6. Or approved equal.

IDENTIFICATION TAGS

1. Hermes Plastics, Inc.
2. Or approved equal.

26 05 23 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

UTP CABLE

1. 3M.
2. Belden CDT Inc.; Electronics Division.
4. CommScope, Inc.
5. Draka USA.
7. KRONE Incorporated.
8. Mohawk; a division of Belden CDT.
9. Nordex/CDT; a subsidiary of Cable Design Technologies.
10. Superior Essex Inc.
11. SYSTIMAX Solutions; a CommScope, Inc. brand.
12. Tyco Electronics/Amp Netconnect; Tyco International Ltd.
13. Or approved equal.

UTP CABLE HARDWARE

2. Dynacom Corporation.
3. Hubbell Premise Wiring.
4. KRONE Incorporated.
5. Leviton Voice & Data Division.
6. Molex Premise Networks; a division of Molex, Inc.
7. Nordex/CDT; a subsidiary of Cable Design Technologies.
8. Panduit Corp.
10. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
11. Or approved equal.

IDENTIFICATION PRODUCTS

1. Brady Corporation.
2. HellermannTyton.
3. Kroy LLC.
4. Panduit Corp.
5. Or approved equal.

26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

GROUND RODS

1. Apache Grounding/Erico Inc.
2. Copperweld, Inc.
3. Erico, Inc.
4. O-Z Gedney Co.
5. Thomas & Betts, Electrical Corp.
6. Or approved equal.

MECHANICAL CONNECTORS

1. Apache Grounding/Erico Inc.
2. Copperweld, Inc.
3. Erico, Inc.
4. ILSCO Corporation.
5. O-Z Gedney Co.
6. Thomas & Betts, Electrical.
7. Or approved equal.

EXOTHERMIC CONNECTIONS

1. Apache Grounding/Erico Inc.
2. Cadweld, Erico, Inc.
3. Copperweld, Inc.
4. Ilsco Corporation.
5. O-Z Gedney Co.
6. Thomas & Betts, Electrical.
7. Or approved equal.

26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

CHANNEL SUPPORTS
2. Steel City/Kindorf.
4. Unistrut.
5. Or approved equal.

FASTENERS
1. Caddy.
2. Construction Engineered Attachment Solutions
3. Pentair Electrical & Fastening Solutions
4. Steel City.
5. T&B.
6. Tomic
7. Or approved equal.

EXPANSION BOLTS
1. Hilti Red Head.
2. SMACNA approved type.
3. Or approved equal.

MECHANICAL SLEEVE SEALS
1. NMP Corporation.
2. Thunderline Link-Seal, Inc.
3. Or approved equal.

FIRESTOPPING
1. 3M Fire Protection Products.
2. Dow Corning Corp.
3. Fire Trak Corp.
4. Hilti Corp.
5. International Protective Coating Corp.
7. Or approved equal.

STEEL-SLOTTED SUPPORT SYSTEMS
1. Allied Tube & Conduit
2. Cooper B-Linie, Inc; a Division of Cooper Industries.
3. ERICO International Corporation.
4. GS Metals Corp.
5. Thomas & Betts Corporation.
6. Unistrut; Tyco International, Ltd.
7. Wesanco, Inc.
8. Or approved equal.

POWDER-ACTUATED FASTENERS

1. Hilti Inc.
2. ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
3. MKT Fastening, LLC.
4. Simpson Strong-Tie Co., Inc.; MasterSet Fastening Systems Unit.
5. Or approved equal.

MECHANICAL-EXPANSION ANCHORS

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Empire Tool and Manufacturing Co., Inc.
3. Hilti Inc.
4. ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
5. MKT Fastening, LLC.
6. Or approved equal.

26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

METAL CONDUIT AND TUBING

1. AFC Cable Systems, Inc.
2. Alflex, Inc.
3. Allied Tube & Conduit, a Tyco International Ltd. Co.
5. Electri-Flex Co.
7. Maverick Tube Corporation.
10. Or approved equal.

NON-METALLIC CONDUIT AND TUBING

1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc; Anaconda Metal Hose.
3. Amco Corporation.
4. CANTEX, Inc.
7. ElecSYS, Inc.
8. Electri-Flex, Co.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT/Cole-Flex.
11. RACO; a Hubbell Company.
12. Thomas & Betts Corporation.
13. Or approved equal.
OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

1. Amco Corporation.
2. Endor Industries Inc.
3. IPEX Inc.
4. Lamson & Sessions; Carlon Electrical Products.
5. Or approved equal.

METAL WIREWAYS

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.
4. Or approved equal.

SURFACE RACEWAYS

1. Thomas & Betts Corporation.
3. Wiremold Company (The); Electrical Sales Division.
4. Or approved equal.

BOXES, ENCLOSURES, AND CABINETS

1. Cooper Cross-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
7. RACO; a Hubbell Company.
10. Spring City Electrical Manufacturing Company.
14. Or approved equal.

POLYMER-CONCRETE HANDHOLES AND BOXES WITH POLYMER-CONCRETE COVER

1. Armorcast Products Company.
2. Carson Industries LLC.
3. CDR Systems Corporation.
5. Or approved equal.

FIBERGLASS HANDHOLES AND BOXES

1. Carson Industries, LLC.
2. Christy Concrete Products.
3. Nordic Fiberglass, Inc.
4. Or approved equal.

**26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS**

**NON-METALLIC DUCTS AND DUCT ACCESSORIES**

1. ARNCO Corp.
2. Beck Manufacturing.
3. Cantex, Inc.
6. ElecSys, Inc.
7. Electri-Flex Company.
8. IPEX Inc.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT; a division of Cable Design Technologies.
11. Spiraduct/AFC Cable Systems, Inc.
12. Or approved equal.

**PRECAST CONCRETE HANDHOLES AND BOXES**

1. Carder Concrete Products.
2. Christy Concrete Products.
3. Elmhurst-Chicago Stone Co.
5. Riverton Concrete Products; a division of Cretex Companies, Inc.
6. Utility Concrete Products, LLC.
8. Wausau Tile, Inc.
9. Or approved equal.

**POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER**

1. Armorcast Products Company.
2. Carson Industries LLC.
3. CDR Systems Corporation.
5. Or approved equal.

**FIBERGLASS HANDHOLES AND BOXES WITH POLYMER CONCRETE FRAME AND COVER**

1. Armorcast Products Company. b. Carson Industries LLC.
2. Christy Concrete Products.
4. Or approved equal.

**FIBERGLASS HANDHOLES AND BOXES**

1. Carson Industries LLC.
2. Christy Concrete Products.
3. Nordic Fiberglass, Inc.
4. Or approved equal.
HIGH-DENSITY PLASTIC BOXES
1. Carson Industries LLC.
2. Nordic Fiberglass, Inc.
4. Or approved equal.

UTILITY STRUCTURE ACCESSORIES
1. Bilco Company (The).
2. Campbell Foundry Company.
3. Carder Concrete Products.
4. Christy Concrete Products.
5. East Jordan Iron Works, Inc.
7. McKinley Iron Works, Inc.
13. Riverton Concrete Products; a division of Cretex Companies, Inc.
14. Strongwell Corporation; Lenoir City Division.
15. Underground Devices, Inc.
16. Utility Concrete Products, LLC.
17. Utility Vault Co.
18. Wausau Tile, Inc.
19. Or approved equal.

CONDUCTING COMPOUND COATING FOR THREADED ENDS OF CONDUITS
1. Thomas & Betts.
2. Or approved equal.

CONDUIT SEALING BUSHINGS
1. Type CSB by O/Z Gedney
2. Or approved equal.

FITTINGS FOR VERTICAL CONDUIT PENETRATIONS IN CONCRETE FLOORS
1. Type FSK Floor Seals by OZ/ Gedney
2. Or approved equal.

FITTINGS FOR VERTICAL CONDUIT PENETRATIONS IN CONCRETE WALLS
1. Type WSK Thruwall by OZ Gedney.
2. Or approved equal.

26 05 44 – SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

SLEEVE-SEAL SYSTEMS
1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.
6. Or approved equal.

SLEEVE-SEAL FITTINGS

1. Presealed Systems.
2. Or approved equal.

26 05 48 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

VIBRATION ISOLATORS

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
4. Isolation Technology, Inc.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
10. Or approved equal.

SEISMIC-RESTRAINT DEVICES

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
4. Hilti Inc.
5. Loos & Co.; Seismic Earthquake Division.
7. TOLCO Incorporated; a brand of NIBCO INC.
8. Tomarco
9. Unistrut; Tyco International, Ltd.
10. Or approved equal.
Standards Adoption

The “Electrical – Cables, Conduits, and Supports” A&E Standards, Version 3.2, August 2018 were adopted by the Standards Committee on August 20, 2018, and are effective immediately.

Confirmed:

[Signature]

Geoffrey W. Neumayr, Standards Committee Chair