Smithsonian Institution

Office of Planning, Design & Construction

SPECIFICATIONS

PROJECT NO.: **2533105**

PROJECT TITLE: **Construct Arabian Leopard Facility (ALF)**

FACILITY: **National Zoological Conservation Biology Institute (NZCBI)**

PACKAGE: **Phase 1 - Issued for Bid - Addendum 1**

DATE: May 11, 2026

This project is approved as being in conformance with applicable provisions of the Smithsonian Directive (SD) 410.

Michael J. Carrancho, P.E., Deputy Director Date

600 Maryland Avenue, S.W.
Suite 5001
Washington, D.C. 20024
Voice: 202.633.6230 Fax: 202.633.6233

USPS Mail: OPDC Capital Gallery
MRC 511
P.O. Box 37012
Washington, D.C. 20013-7012

TABLE OF CONTENTS

DIVISION 31 - EARTHWORK

DIVISION 33 - UTILITIES

END OF TABLE OF CONTENTS

SECTION 26 0400 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Design Intent:
1. The Contract Documents indicate and specify the electrical design intent. The Contract Drawings are schematic and diagrammatic and are not intended to indicate construction details and routing unless specifically indicated. The specifications establish minimum performance, product and installation requirements.
2. In addition to the specified and indicated performance and quality requirements, furnish products and perform installation work consistent with the design intent, industry standards and as necessary to the provision of complete operating electrical systems.
3. Install electrical work in accordance with the National Electrical Code and all applicable local codes in a neat and workmanlike manner.
4. This Section specifies basic electrical requirements applicable to all Divisions unless explicitly excepted.
5. If there is a conflict between applicable documents, then the more stringent requirement shall apply. All documents listed are believed to be the most current releases of the documents. The Contractor has the responsibility to determine and adhere to the most recent release when developing the proposal for installation.
6. Contractor shall thoroughly review entire set of Contract Documents, including all discipline drawings and specifications prior to bidding and include all required electrical work in bid, even if not explicitly shown on electrical Drawings and Specifications.
7. The project is pursuing LEED certification. Contractor shall provide requirements in compliance with LEED and WELL standards as identified in the Contract Documents.

1.2 REFERENCES

A. American National Standards Institute (ANSI) C2 - National Electrical Safety Code.

B. City of Washington Ordinances.

C. State of District of Columbia Codes.

D. National Electrical Contractors Association (NECA).
1. 1 - Standard for Good Workmanship in Electrical Construction.
2. 500 - Recommended Practice for Installing Indoor Commercial Lighting Systems.

E. National Fire Protection Association (NFPA).
1. 70 - National Electrical Code (NEC).
2. 70E - Standard for Electrical Safety in the Workplace.
3. 72 - National Fire Alarm and Signaling Code.
4. 101 - Life Safety Code.
5. 111 - Standard for Stored Electrical Energy Emergency and Standby Power Systems.

1.3 SUBMITTALS

A. General

1. Submit Shop Drawings, Product Data, Samples and other specified submittals on a "system" basis. Retain, and assemble drawings and data from manufacturer or component manufacturers such that each submittal is for a complete system.
2. Refer to Section 01 3300, "Shop Drawings, Product Data and Samples", for basic definitions and requirements for submittals.
3. Refer to Section 01 3330 for submittal compliance form.

B. Quality Control Submittals
1. Submit results of factory tests two weeks prior to product shipment from factory.
2. Submit results of field tests immediately upon completion of the field test.

C. Contract Closeout Submittals
1. Refer to Division 01, "Record Documents", for basic definitions and requirements for record documents.
2. Submit, at the completion of the work, record drawings per Division 01 and in an approved electronic format matching the electronic format in which the construction documents were produced. Indicate the actual electrical installation, size and construction details. Include the following information:
   a. Lighting layout, type, circuit designation and control, including each conduit and wire as installed.
   b. Power distribution system, including distribution equipment and each conduit and wire size installed.
   c. Layout and circuiting for wiring devices, surface raceways and related equipment, including location of all outlets, junction boxes, and conduit runs, including conduit size, circuit numbers, and number of wires in each run.
   d. Layout and circuitry for power circuits to mechanical equipment and other electrified building equipment, including each conduit and wire size.
   e. Supporting and mounting details.
      1) Special systems layouts such as fire alarm, security, lighting control, and telecommunications systems.
   f. Layout, cabling and circuiting of site electrical systems such as underground duct banks, manholes, hand holes and site lighting fixtures. Include system and cable identification of communication systems such as telephone, data, fiber optic, fire alarm, security system and other cabling systems.
   g. Panel schedule drawings consisting of each panelboard. Schedules shall indicate the ”as built circuiting with loads and room numbers identified. Room numbers on schedules shall include the architectural room number indicated on the Drawings and the signage room numbers from the signage schedules. Each circuit in the panel schedules shall be uniquely identified, regardless of how they are indicated on the construction documents.
   h. Layout and location of above ceiling devices, including, but not limited to, controllers, control panels, emergency load transfer devices, power supplies, relays, battery packs and all other electrical equipment and products requiring maintenance, service, adjustment or replacement in the future.

1.4 QUALITY ASSURANCE

A. Owner Construction Design Standards
1. Provide an electrical installation in accordance with the Owner's construction design standards and specifications, unless specific written waivers are provided by the Owner.

B. Regulatory Requirements
1. Comply with the applicable requirements of ANSI C2 and the latest NFPA 70.
a. Requirements of ANSI C2 and NFPA 70 shall be minimum standards of products and installation work. Furnish products and perform installation work which exceed the standards of ANSI C2 and NFPA 70 when specified or indicated.
2. Comply with applicable requirements of city, county, and state laws, ordinances and regulations including modifications and supplements to ANSI C2 and NFPA 70.
3. Comply with the applicable requirements of U.S.Department of Labor, Occupational Safety and Health Administration Standards (OSHA).
4. All materials shall conform with the standards of the Underwriter¢s Laboratories in every case where such standards have been established for the particular type of material or assembly .
5. All material and equipment shall be UL listed and bear the UL label where such listing and labeling exists.
6. In the case where two or more Codes conflict or contradict each other, comply with the more stringent Code or standard.

C. Contractor Qualifications and Character of Work
1. Contractor personnel must be knowledgeable in local, state and national codes and regulations. Contractor shall have been in the business of installing electrical systems for a minimum of ten (10) years.

2. Contractor shall have experience working in the **[District of Columbia]**

3. Contractor must possess and maintain current liability insurance certificates.
4. Contractor shall obtain and pay for all permits and inspections required by laws, local ordinances, rules, and regulations having jurisdiction for the work. Permits shall be readily available and posted in a prominent place at building site and protected from weather and physical damage.
5. The installation shall be executed in a workmanlike manner and shall present a neat physical appearance when completed.

D. Coordination
1. Utilities.

a. Coordinate work related to utility services with the appropriate utility companies. Comply with the requirements of the following companies:
1) Electrical power: Potomac Electric Power Company (PEPCO).

1.5 PROJECT/SITE CONDITIONS

A. Environmental Requirements
1. Provide products suitable for operation under the following environmental conditions:
a. Temperature: -18 to 38 degrees C (0 to 100 degrees F).
b. Humidity: 0 to 95 relative percent, non-condensing.
c. Altitude: 2010 meters (6600 feet) above sea level.
d. Outdoor: Products that are UL listed for wet locations.

1.6 WARRANTIES

A. Refer to the Conditions of the Contract for provisions concerning Contract general warranty, Statements of Compliance, correction of Work period, and form of Special Warranty.

B. All electrical systems, equipment and installations shall be provided with a one-year minimum Warranty starting from the date of substantial completion.

C. During the warranty period, and for non-conformities the contractor shall take all necessary and appropriate action; free of charge, to correct any non-conformity with the warranties contained in the manufacturer agreement. During the warranty period, contractor shall provide to Owner, free of costs and charges, all support necessary to ensure that the installation meets the requirements specified in the Contract Documents and performance guarantees provided by the contractors. During the warranty period, contractors shall furnish, or cause to be furnished, all maintenance, service, parts and replacements necessary to maintain the installation in good working condition, at no cost to Owner.

1.7 CONDUCTOR SIZING

A. Feeder and Branch Circuit Sizing
1. Provide feeder and branch circuits per the circuit sizing schedules indicated on Drawings. Where schedules are not indicated, provide conductors which are sized as required per the NEC for the indicated overcurrent protective device rating. Circuit sizing and installation shall consider the field routing and anticipated voltage drop. Upsize wire, as necessary, to compensate for voltage drop and/or other forms of derating required in accordance with the NEC.
2. Derate conductor ampacities per the NEC for field conditions including but not limited to conduits exposed to sunlight, elevated ambient temperature, and/or more than 3 current carrying conductors in a raceway.

1.8 SYSTEMS INTEGRATION

A. Coordinate with equipment suppliers and ensure integration of systems comprised of disparate equipment which work together to form a complete system.

B. Provide all miscellaneous components, wiring, hardware, etc. required for complete and operational equipment and systems whether or not these items are explicitly shown in the Contract Documents.

C. Provide systems which maintain the UL rating of the individual pieces of equipment.

D. Submit system integration wiring diagrams, control diagrams and sequence of operation, as needed.

1.9 COORDINATION

A. Contractor shall participate in the project scheduling, coordination meetings and coordination drawing/modeling activities as specified in Division 01.

B. All potential coordination issues shall be brought to the attention of the Construction Manager immediately before proceeding with the installation.

C. Contractor shall be responsible for all cross connecting and coordination with vendors and other trade contractors to provide complete operational systems.

D. For purpose of clarify and legibility, drawings are diagrammatic. Locate equipment as close as practical to the locations shown on the drawings. Should field conditions prevent the installation of equipment or materials as indicated on the drawings, make deviations only with the prior approval of the Owner's representative.

E. Coordinate arrangement, mounting, and support of electrical equipment:
1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping at required slope.
4. To allow connecting raceways, cables, wireways, cable trays, and busways to be clear of obstructions and of the working and access space of other equipment.

F. Coordinate work with other trades to ensure completion is consistent with the project schedule. Ensure the NEC-required working space and dedicated electrical space about electrical equipment is provided. Foreign systems shall not be located within these dedicated zones. Any work that encroaches on the working space or dedicated electrical space shall be relocated at the Contractor's expense.

G. Equipment and device mounting heights and alignment shall adhere to architectural drawings, rules and requirements. Devices of all trades within the same general area shall be coordinated prior to construction. Care shall be taken to align devices horizontally and vertically. Devices that are not aligned properly shall be relocated at the Contractor's expense.

H. Coordinate exact conduit routing in the field with other trades and with building elements such as structural steel members. Conduit and raceways are not explicitly shown. Conduit routing where shown on drawings shall be considered approximate. Contractor shall be responsible for final routing in the field and shall be responsible for complete coordination with all other trades.

I. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

J. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 8.

K. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. General
1. Furnish products by one of the equipment manufacturers listed under the heading "Manufacturers" within the applicable sections. When given, furnish the specified product model or brand for the selected manufacturer.

2. Provide products, for which quantities of two or more are to be furnished, from the same manufacturer and of the same product or model series.
3. Furnish product components designed to be used together and which are physically and electrically compatible.

B. Comparable Products
1. Comparable products may be proposed when the "or as approved" clause is specified under the heading "Manufacturers". Submit such products substitutions for approval per Division 01, "Product Requirements."

C. Product Substitutions
1. Product substitutions may be requested under the conditions specified in Division 1 "Substitution Procedures." Submit product substitutions for consideration per Division 01, "Substitution Procedures".

2.2 PRODUCTS

A. Product Listing and Labeling
1. Provide listed and labeled product for which listings and labels exist by Underwriters Laboratories Inc. (UL), Factory Mutual (FM), or similar independent testing organizations recognized by the authorities having jurisdiction. For products for which there are no such listings and labels, provide listed and labeled components of those products, for which component listing and labels exist.

B. PCB Content Prohibited
1. Provide products which do not contain any amounts of polychlorinated biphenyl (PCB) compounds.

C. Asbestos Content Prohibited
1. Provide products which do not contain any amounts of asbestos.

D. Access Doors
1. Provide access doors necessary to access devices, whether for control or maintenance, governed by these Basic Electrical Materials and Methods. Comply with access door requirements specified in Division 08. Access doors are not explicitly shown on the Drawings.
2. Access doors shall be coordinated with other trades and final locations shall be approved by Architect. Access doors not approved by Architect shall be removed or relocated at the Contractors expense.
3. Access doors installed in fire rated floors, walls or ceilings shall be sufficiently rated to maintain the rating of the surface where installed.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests
1. Permit Architect and Owner to observe factory tests. Provide minimum five working days' notice of factory tests.
2. Schedule no more than one equipment or system factory test per week.

PART 3 - EXECUTION

3.1 [CONSTRUCTION PHASING

A. The project will utilize phased construction. Contractor shall account for any and all costs associated with a phased construction schedule in bid.]

3.2 SHUTDOWNS

A. Interruption of Existing Service: Do not interrupt electric, communications or fire alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Architect, Construction Manager and Owner no fewer than seven days in advance of proposed interruption of service.
   2. Indicate method of providing temporary service.
   3. Do not proceed with interruption of service without Architect's, Construction Manager's and Owner’s written permission.
   4. Comply with NFPA 70E.

B. Coordinate all service interruptions with other disciplines and Owner's representative. Shutdowns shall be performed during off hours, which may include weekends or holidays. This premium time cost shall be included in the Contractor's base bid.

C. Maintain Owner communications and network services operations during construction. Coordinate all service interruptions with other disciplines and Owner's representative.

D. Maintain Owner fire alarm systems and services operations during construction. Coordinate all service interruptions with other disciplines and Owner's representative.

3.3 DEMOLITION

A. Protect adjacent building services and materials indicated to remain. Install and maintain barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition is complete.

B. “Carefully remove, clean and restore and reinstall items that are relocated during construction to a "like new" condition.

C. Building elements such as walls, partitions, floors and ceilings affected by electrical construction such as conduit penetrations shall be repaired, patched, painted and otherwise restored to a "like new" condition.

D. Lamp and Ballast Recycling.
   1. Recycle lamps, ballasts and drivers containing hazardous materials such as mercury during construction. These shall include tubular fluorescent, compact fluorescent, HID, LED, induction and cold cathode lamps. These lamp types, ballasts and drivers associated with these lamps shall not be disposed of as solid municipal waste.

E. Equipment Protection and Cleanup.

1. Protect equipment and materials during shipment, storage and construction against damage, dust and contamination. Items that become damaged, dirty or contaminated during construction shall be restored to a "like new" condition or replaced at the Contractor's expense.
2. Remove and legally dispose of demolished items, rubbish, debris and construction waste from the construction site daily, and at the completion of the work. The contractor shall maintain a "clean" work site. Failure to do so may result in the cleanup being performed by others and all costs thereof being deducted from the Contractor's final payment.

3.4 TEMPORARY SERVICE

A. The facility will remain operational during construction. Provide equipment, hardware, wiring, etc. to maintain systems scheduled to remain operational during construction. Coordinate detailed work phasing plans with the Construction Manager, Architect and Owner prior to commencing work.

B. Provide, maintain and remove all temporary lighting, power and communications required to complete the project.
1. Coordinate temporary service installation with the local utility companies and building landlord prior to construction.

C. In addition to NEC ground fault protection requirements, provide ground fault protection on temporary feeders 200 amps and greater.

D. Temporary feeders shall be limited to the following types:
1. Conductors installed in raceways.
2. Type MC cable.
3. Multi-conductor cable with an overall protective outer jacket (where inaccessible to the public and not subject to physical damage or abuse).
4. NEC recognized hard usage cord (where inaccessible to the public and not subject to physical damage or abuse).
5. Label temporary feeders every 25 feet maximum

3.5 INSTALLATION

A. General
1. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items, unless otherwise indicated.
2. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
3. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
4. Right of Way: Give to piping systems installed at a required slope.

B. Wiring Installation
1. Install wiring for control systems, power feeder and branch circuits, lighting branch circuits, communication and auxiliary systems, such as fire alarm and security, in separate raceways unless otherwise indicated.

2. Install wiring and devices and make connections for Owner furnished equipment and furnished under other sections of the specifications such as, but not limited to, automatic doors, projection screens, pneumatic tube stations, casework, medical headwalls, radiation oncology equipment, diagnostic imaging equipment and laboratory equipment. Refer to the specific sections for electrical requirements. Coordinate installation with the equipment supplier and the approved shop drawings.
3. Prior to rough-in of electrical and telecommunications devices, verify locations with the owner's final furniture plans and the system supplier's approved installation drawings. Adjust locations of devices to coordinate with furniture and equipment layouts.

C. Device Location
1. Allow for relocation prior to installation of wiring devices and other control devices, for example, receptacles, switches, occupancy sensors, fire alarm devices and access control devices, within a 10-foot radius of indicated location without additional cost.
2. Refer to architectural plans for device location, mounting and alignment rules and requirements. Coordinate all device and lighting fixture placement with other trades prior to rough-in.
3. Devices in proximity to each other shall be horizontally and vertically aligned. Devices which are not aligned properly shall be relocated as required to meet alignment requirements at no cost to Owner.
4. Coordinate device placement and installation with other trades and Architect/Engineer prior to construction and rough-in.

D. NECA Compliance
1. Install products in accordance with applicable NECA Standards, unless otherwise specified or indicated.

E. Wet, Damp, or Dry Location Work
1. Provide products as appropriate for wet, damp, or dry locations as defined by NFPA 70.

F. Manufacturer Installation Instructions
1. Install equipment in accordance with the manufacturer's installation instructions and recommendations.

G. Fire and Smoke Barrier Penetrations
1. Install firestopping to raceways, boxes and electrical equipment installed in or penetrating fire-rated floor and wall assemblies and smoke barrier assemblies, in a manner which maintains the fire resistance rating or barrier intent.

H. Field Painting
1. Refer to Division 09 for prime and finish field painting requirements.
2. Field paint electrical equipment, products, materials, components and systems where indicated.
3. In a manner approved by the manufacturer and satisfactory to the Owner, touch-up or refinish factory-applied paints or finishes which are chipped, defaced, scratched, or in any other way disturbed due to handling, installation, or general construction work.

I. Exposed Construction

1. Take care in areas where the installation is exposed and visible to the public. Install electrical systems and equipment in an organized fashion and field painted. Mounting surfaces shall be repaired, patched, and painted to provide a "like new" appearance.
2. Coordinate systems (e.g. conduit, cable tray, wiring, duct work, piping, hanger, supports, etc.) prior to installation.

J. Personnel Protection from Suspended Work
1. Where suspended equipment, piping or ductwork or any of their supporting or reinforcing members extend 2.1 meters (7 feet) or less above the floor or any other walking surface, cover all edges, projecting surfaces and sharp corners with pre-fabricated soft rubber pads, elastomeric insulation, caps or equivalent to prevent injury to personnel.

3.6 ACCEPTANCE TESTING

A. General.
1. Provide necessary test equipment and be responsible for setting-up test equipment, wire checks of factory wiring and any other preliminary work in preparation for the electrical acceptance tests.
2. Perform tests which do not exceed the manufacturer's recommended limit for the equipment being tested.
3. Where required for the validity of tests or safety of equipment and personnel, isolate equipment to be tested from the system.
4. Include the ambient temperature and relative humidity existing at the time when performing insulation resistance, dielectric absorption or high potential tests.
5. Coordinate testing and inspections with commissioning agent.

B. Visual Inspections.
1. Prior to any testing, perform visual inspections to verify the following:
   a. The equipment is completely and properly installed.
   b. The equipment is free from damage and defects.
   c. Shipping blocks and restraints have been removed.`
   d. Electrical terminations are properly tightened.
   e. The equipment is properly aligned.
   f. The equipment is properly lubricated.
   g. The ventilation louvers are open and unobstructed.
   h. The equipment is ready to be tested.

C. Manual Operation.
1. Prior to any testing, operate mechanical devices to verify that they function properly and freely.

D. Insulation Resistance Test.
1. Perform test with a voltage source capable of providing a constant direct voltage for the time intervals as specified below.
   a. 150 volts and under - 500 volts.
   b. 151-600 volts - 1000 volts.
   c. Hold 1000-volt and 500-volt insulation resistance tests for a minimum of one minute or until the reading reaches a constant value for 15 seconds unless specified otherwise.
   d. Apply tests from phase to ground with the other phases grounded. Test each phase in a similar manner.

e. Check phase matching and phase identification immediately prior to energizing equipment.

3.7 FIELD QUALITY CONTROL

A. Field Tests
1. Permit Architect and Owner to observe field tests. Provide minimum sevenworking days' notice of field test.
2. Schedule tests in coordination with other Contract work. Schedule no more than one equipment or system field test per day.
3. Provide test reports.

B. Inspect installed sleeves and firestopping for damage or faulty work. Replace defective installations.

C. Replace any equipment, system or materials found to be defective or found to be of lesser quality than that specified or shown on the Drawings.

3.8 CLEANING

A. Clean electrical equipment and systems to remove dirt, paint or other foreign materials and restore to match original condition and finish upon completion of construction.

3.9 TRAINING

A. General
1. Provide training for Owner's personnel in the operation and maintenance of equipment as specified in the applicable Section for the particular equipment and system.
2. Develop training schedule which is acceptable to the Owner. Submit schedule for approval.
3. Provide instruction books, manuals, and other classroom material required as part of the training sessions.
4. Provide instructors who are certified by the equipment and system manufacturers.
5. Provide training for a minimum of three of the Owner's personnel, or as specified in the applicable Section.
6. Conduct training at Project Site after the equipment/system has been installed.

B. Operations and Maintenance Training
1. Train personnel in all aspects of normal operation of the equipment, including starting, adjustments while running, and shutdown.
a. Train personnel to recognize incipient problems, including inefficient or dangerous modes of operation, and provide instruction in corrective actions to be taken.
2. Train personnel to perform all recommended maintenance on the equipment.

END OF SECTION

SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Schedule: Indicate type, use, location, and termination locations.

1.2 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **testing agency**.

B. Field quality-control reports.

1.3 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Standards:
   1. Products listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   2. RoHS compliant.
   3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Alpha Wire Company.
   2. American Bare Conductor.
   3. Belden Inc.
   4. Cerro Wire LLC.
   5. Encore Wire Corporation.
   6. General Cable Technologies Corporation.
   7. Okonite Company (The).
   8. Service Wire Co.
   9. Southwire Company.
   10. WESCO.

C. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 and ASTM B 496 for stranded conductors.

D. Conductor Insulation:

1. Refer to Part 3 for conductor insulation application. Comply with UL Standard appropriate for cable insulation.

2.2 MINERAL-INSULATED CABLE, TYPE MI

A. Description: Solid copper conductors encased in compressed metal oxide with an outer metallic sheath, rated 600 V or less.

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

C. Standards:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. UL 2196 for fire resistance.

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper.

E. Insulation: Compressed magnesium oxide, minimum 55 mils for 600 volt power and control cables; minimum 23 mils for 300 volt twisted pair cables.

F. Sheath: Copper, continuous and seamless, liquid- and gas-tight.

2.3 TRAY CABLE, TYPE TC FOR VFD OUTPUT CIRCUITS

A. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in a nonmetallic jacket.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Alpha Wire Company.
2. Belden Inc.
3. Encore Wire Corporation.
4. General Cable Technologies Corporation.
5. Okonite Company (The).
6. Service Wire Co.
7. Southwire Company.
8. WESCO.

C. Standards:
1. RoHS compliant.
2. Comply with UL 1277.
3. Comply with ICEA S-95-658/NEMA WC 70 for Type TC cables used for power distribution.

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

E. Ground Conductor: Three stranded bare copper ground wires.

F. Conductor Insulation: Type XHHW-2 or RHW-2. Comply with UL 44.

G. Shield: Copper tape shield with a minimum of 50% overlap.

2.4 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. 3M Electrical Products.
2. AFC Cable Systems; a part of Atkore International.
3. Gardner Bender.
4. Hubbell Power Systems, Inc.
5. Ideal Industries, Inc.
6. ILSCO.
7. NSi Industries LLC.
8. O-Z/Gedney; a brand of Emerson Industrial Automation.
9. Service Wire Co.
10. TE Connectivity Ltd.
11. Thomas & Betts Corporation; A Member of the ABB Group.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
1. Material: Bronze or matching conductor material.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

D. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

E. Isolated Power System Secondary Conductor Type: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

F. Feeders: Type THHN/THWN-2 or XHHW-2, single conductors in raceway.

G. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway .

H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway .

I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2 or XHHW-2, single conductors in raceway .

J. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway .

K. Feeders and Branch Circuits Installed on Rooftops: Type XHHW-2, single conductors in raceway.

L. Emergency Power System Branch Circuits: Type THHN-2/THWN-2, single conductors in raceway.

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

N. VFD Output Circuits: Type TC-ER cable with tape shield.

O. Smithsonian Design Standard: The use of Metal Clad (MC) cable for power and lighting branch circuits will be reviewed with SI for specific project requirements. The basis of design will include branch circuits run in Electrical Metallic Tubing (EMT) conduit, with a 1.8m (6ft) maximum whip length from junction box to lighting fixture position. MC cable for overall branch circuit length is not permitted.

P. Smithsonian Design Standard: Wet Locations: Type XHHW-2, single conductors in raceway.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

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

B. Complete raceway installation between conductor and cable termination points according to Section 26 0533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

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

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

F. Support cables according to Section 26 0529 "Hangers and Supports for Electrical Systems."

G. Install cable per manufacturer's recommendations.

3.3 CONNECTIONS

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

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm).

3.4 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 26 0553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 07 8413 "Penetration Firestopping."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:
1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION

SECTION 26 0543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
2. Rigid nonmetallic duct.
3. Flexible nonmetallic duct.
4. Duct accessories.
5. Precast concrete handholes.
6. Polymer concrete handholes and boxes with polymer concrete cover.
7. Precast manholes.
8. Utility structure accessories.

1.2 DEFINITIONS

A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.

B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

C. Duct Bank:
1. Two or more ducts installed in parallel, with or without additional casing materials.
2. Multiple duct banks.

D. GRC: Galvanized rigid (steel) conduit.

E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include duct-bank materials, including spacers and miscellaneous components.
2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for manholes, handholes, boxes, and other utility structures.
4. Include underground-line warning tape.

B. Shop Drawings:
1. Precast or Factory-Fabricated Underground Utility Structures:
   a. Include plans, elevations, sections, details, attachments to other work, and accessories.
   b. Include duct entry provisions, including locations and duct sizes.
   c. Include reinforcement details.
   d. Include frame and cover design and manhole chimneys.

e. Include ladder or step details.
f. Include grounding details.
g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
h. Include joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:
a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including locations and duct sizes.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

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

C. Source quality-control reports.

D. Field quality-control reports.

1.5 MAINTENANCE MATERIALS SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.7 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:
1. Notify Construction Manager and Owner no fewer than five days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's written permission.

B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

A. GRC: Comply with ANSI C80.1 and UL 6.

B. Coated Steel Conduit: PVC-coated GRC IMC.
1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems; a part of Atkore International.
2. Allied Tube & Conduit; a part of Atkore International.
3. Anamet Electrical, Inc.
4. Calconduit.
5. Electri-Flex Company.
6. FSR Inc.
7. Korkap.
8. Opti-Com Manufacturing Network, Inc (OMNI).
9. O-Z/Gedney; a brand of Emerson Industrial Automation.
10. Perma-Cote.
11. Picoma Industries, Inc.
12. Plasti-Bond.
13. Republic Conduit.
14. Southwire Company.
15. Thomas & Betts Corporation; A Member of the ABB Group.
16. Topaz Electric; a division of Topaz Lighting Corp.
17. Western Tube and Conduit Corporation.
18. Wheatland Tube Company.

D. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EPC-80-PVC and Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ARNCO Corp.
2. Beck Manufacturing.
3. CANTEX INC.
4. CertainTeed Corporation.
5. Condux International, Inc.
6. Crown Line Plastics.
7. ElecSys, Inc.
8. Electri-Flex Company.
9. Endot Industries Inc.

10. IPEX USA LLC.
11. Lamson & Sessions.
12. Manhattan/CDT.
13. National Pipe & Plastics.
14. Opti-Com Manufacturing Network, Inc (OMNI).
15. Spiraduct/AFC Cable Systems, Inc.

C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

1. VOC Content:[510] <Insert value> g/L or less for PVC conduit and fittings.

2.3 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

1. Manufacturers: Subject to compliance with requirements,provide products by one of the following:
   a. Allied Tube & Conduit; a part of Atkore International.
   b. CANTEX INC.
   c. Carlon; a brand of Thomas & Betts Corporation.
   d. IPEX USA LLC.
   e. PenCell Plastics.
   f. Underground Devices, Inc.

B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 26 0553 "Identification for Electrical Systems."

C. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 75 mm) in size, manufactured from 6000-psi (41-MPa) concrete.
1. Color: Red dye added to concrete during batching.
2. Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.

2.4 PRECAST CONCRETE HANDHOLES AND BOXES

A. 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 handhole or box.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Christy Concrete Products.
2. Elmhurst-Chicago Stone Co.
3. Oldcastle Precast, Inc.
4. Rinker Group, Ltd.
5. Riverton Concrete Products.

6. Utility Concrete Products, LLC.
7. Utility Vault Co.
8. Wausau Tile Inc.

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

D. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
1. Cover Hinges: Concealed, with hold-open ratchet assembly.
2. Cover Handle: Recessed.

E. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

F. Cover Legend: Molded lettering, "ELECTRIC." as indicated for each service. Insert legend.

G. Configuration: Units shall be designed for flush burial and have open closed integral closed bottom unless otherwise indicated.

H. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
1. Center window location.
2. Knockout panels shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
4. Knockout panels shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
5. Knockout panels shall be 1-1/2 to 2 inches (38 to 50 mm) thick.

I. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
1. Type and size shall match fittings to duct to be terminated.
2. Fittings shall align with elevations of approaching duct and be located near interior corners of handholes to facilitate racking of cable.

J. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.5 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armorcast Products Company.
2. NewBasis.
3. Oldcastle Enclosure Solutions.

4. Quazite: Hubbell Power Systems, Inc.

C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

D. Color: Gray Green.

E. Configuration: Units shall be designed for flush burial and have open closed integral closed bottom unless otherwise indicated.

F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

H. Cover Legend: Molded lettering, "ELECTRIC." as indicated for each service. Insert legend.

I. 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.

J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.

K. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.6 PRECAST MANHOLES

A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

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

C.

1. Carder Concrete Products.
2. Christy Concrete Products.
3. Elmhurst-Chicago Stone Co.
4. Oldcastle Precast, Inc.
5. Rinker Group, Ltd.
6. Riverton Concrete Products.
7. Utility Concrete Products, LLC.
8. Utility Vault Co.
9. Wausau Tile Inc.

D. Comply with ASTM C 858.

E. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

F. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
1. Center window location.
2. Knockout panels shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
4. Knockout panel shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
5. Knockout panels shall be 1-1/2 to 2 inches (38 to 50 mm) thick.

G. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
1. Type and size shall match fittings to duct to be terminated.
2. Fittings shall align with elevations of approaching duct and be located near interior corners of manholes to facilitate racking of cable.

H. Ground Rod Sleeve: Provide a 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the duct entering the structure.

I. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.7 UTILITY STRUCTURE ACCESSORIES

A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bilco Company (The).
2. Campbell Foundry Company.
3. Carder Concrete Products.
4. Christy Concrete Products.
5. EJ.
6. Elmhurst-Chicago Stone Co.
7. McKinley Iron Works, Inc.
8. Neenah Foundry Company.
9. NewBasis.
10. Oldcastle Precast, Inc.
11. Osburn Associates, Inc.
12. Pennsylvania Insert Corporation.
13. Quazite: Hubbell Power Systems, Inc.
14. Rinker Group, Ltd.
15. Riverton Concrete Products.
16. Underground Devices, Inc.
17. Utility Concrete Products, LLC.
18. Utility Vault Co.

19. Wausau Tile Inc.

C. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
   1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B cast aluminum with milled cover-to-frame bearing surfaces; diameter, 26 inches (660 mm) 29 inches (725 mm).
      a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
      b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
   2. Cover Legend: Cast in. Selected to suit system.
      a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
   3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.

      a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.
      b. Seal joints watertight using preformed plastic or rubber complying with ASTM C 990. Install sealing material according to sealant manufacturers' written instructions.

D. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.

E. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.
   1. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.

F. Pulling-in and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) 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 (180-kN) shear and 60,000-lbf (270-kN) tension.

G. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (31 mm) minimum at base.
   1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.

H. Ground Rod Sleeve: 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.

I. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.

J. Cable Rack Assembly: Steel, hot-rolled hot-dip galvanized, except insulators.

1. Stanchions: T-section or channel with provisions to connect to other sections or channels to form a continuous unit; 1-1/2 inches (38 mm) in width by nominal 24 inches (600 mm) long; punched with 14 hook holes on 1-1/2-inch (38-mm) centers for cable-arm attachment.
2. Arms: 1-1/2 inches (38 mm) wide, lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 18 inches (450 mm) with 250-lb (114-kg) 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.

K. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

L. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin hot-dip galvanized steel.

M. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N) and greater Light duty, designed for lifts less than 60 lbf (270 N). Two Insert number required.

2.8 SOURCE QUALITY CONTROL

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

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Strength tests of complete boxes and covers shall be by an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
2. 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 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

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

C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 31 1000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 31 1000 "Site Clearing."

3.2 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Cables More Than 600 V: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.

B. Duct for Electrical Feeders 600 V and Less: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.

C. Duct for Electrical Branch Circuits: Type EPC-80-PVC RNC, direct-buried unless otherwise indicated.

D. Underground Ducts Crossing Paved Paths Walks and Driveways: Type EPC-40 PVC RNC, encased in reinforced concrete.

E. Stub-ups: Concrete-encased PVC-coated GRC.

3.3 EARTHWORK

A. Excavation and Backfill: Comply with Section 31 2000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation, and re-establish 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 Section 32 9200 "Turf and Grasses" and Section 32 9300 "Plants."

D. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 01 7300 "Execution."

3.4 DUCT AND DUCT-BANK INSTALLATION

A. Install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.

B. Install duct according to NEMA TCB 2.

C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.

D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches (1200 mm) , both horizontally and vertically, at other locations unless otherwise indicated.

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

F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

G. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches (150 mm) o.c. for 4-inch (100-mm) duct, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to terminator spacing 10 feet (3 m) from the terminator, without reducing duct line slope and without forming a trap in the line.

2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line duct with calculated expansion of more than 3/4 inch (19 mm).

H. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet (3 m) outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 26 0544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

I. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

J. Pulling Cord: Install 200-lbf- (1000-N-) test nylon cord in empty ducts.

K. Concrete-Encased Ducts and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 31 2000 "Earth Moving" for pipes less than 6 inches (150 mm) in nominal diameter.

2. Width: Excavate trench 12 inches (300 mm) wider than duct on each side.

3. Depth: Install so top of duct envelope is at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
4. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.

5. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet (6 m) of duct. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) between tiers. Secure spacers to earth and to duct to prevent floating during concreting. 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.

6. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.

7. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
8. 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.

9. Concrete Cover: Install a minimum of 3 inches (75 mm) of concrete cover between edge of duct to exterior envelope wall, 2 inches (50 mm) between duct of like services, and 4 inches (100 mm) between power and communications ducts.
10. 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 duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions, or use other specific measures to prevent expansion-contraction damage.
    b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (15-mm) reinforcing-rod dowels extending a minimum of 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.
11. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 03 3000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

L. Direct-Buried Duct and Duct Bank:
1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 31 2000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches (150 mm) in nominal diameter.
2. Width: Excavate trench 12 inches (300 mm) wider than duct on each side.
3. Width: Excavate trench 3 inches (75 mm) wider than duct on each side.

4. Depth: Install top of duct at least 36 inches (900 mm) below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.

7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet (6 m) of duct. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. 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.

8. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
9. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches (100 mm) over duct 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. Comply with requirements in Section 31 2000 "Earth Moving" for installation of backfill materials.

    a. Place minimum 3 inches (75 mm) of sand as a bed for duct. Place sand to a minimum of 6 inches (150 mm) above top level of duct.
    b. Place minimum 6 inches (150 mm) of engineered fill above concrete encasement of duct.

M. Underground-Line Warning Tape: Bury conducting underground line specified in Section 26 0553 "Identification for Electrical Systems" no less than 12 inches (300 mm) above all concrete-encased duct and duct banks and approximately 12 inches (300 mm) below grade. Align tape parallel to and within 3 inches (75 mm) of centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Cast-in-Place Manhole Installation:
1. Finish interior surfaces with a smooth-troweled finish.

2. Knockouts for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches (38 to 50 mm) thick, arranged as indicated.
3. Comply with requirements in Section 03 3000 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.

B. Precast Concrete Handhole and Manhole Installation:
1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting duct, 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-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevations:
1. Manhole Roof: Install with rooftop at least 15 inches (375 mm) below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
3. Install handholes with bottom below frost line, below grade.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

E. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

F. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 07 1353 "Elastomeric Sheet Waterproofing." or Section 07 1354 "Thermoplastic Sheet Waterproofing." After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

G. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 07 1113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

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

I. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

J. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (97 mm) for manholes and 2 inches (50 mm) for handholes, 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 handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.

D. Install handholes and boxes with bottom below frost line, below grade.

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

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

G. For enclosures installed in asphalt paving and and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
   1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Section 03 3000 "Cast-in-Place Concrete," with a troweled finish.
   2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

3.7 GROUNDING

A. Ground underground ducts and utility structures according to Section 26 0526 "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
   2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch- (300-mm-) long mandrel equal to duct size minus 1/4 inch (6 mm). If obstructions are indicated, remove obstructions and retest.
   3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 0526 "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 duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

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

END OF SECTION