JOINT BASE LEWIS-McCHORD DESIGN STANDARDS

DIVISION 33 - UTILITIES

SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION

07/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI SP-66	(2004) ACI Detailing Manual

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2013) specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B496	(2014) Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-

	Hard, or Soft
ASTM C478	(2015) Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C857	(2014) Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM C990	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM F2160	(2010) Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)
ASTM F512	(2012) Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2006; INT 1 2011) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE 400.2	(2013) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)
IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE 48	(2009) Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2017) National Electrical Safety Code
IEEE C37.20.3	(2013) Standard for Metal-Enclosed Interrupter Switchgear
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions INTERNATIONAL

ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2011) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
ANSI/NEMA WC 71/ICEA S-96-659	(1999) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2015) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 7	(2013) Standard for Smooth-Wall Coilable Electrical Polyethylene Conduit
NEMA TC 9	(2004) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

THE SOCIETY OF CABLE TELECOMMUNICATIONS ENGINEERS (SCTE)

ANSI/SCTE 77	(2013) Specification for Underground Enclosure Integrity

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644	(2002) Underground Plant Construction

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-60005	(Basic; Notice 2) Frames, Covers, Gratings, Steps, Sump And Catch Basin, Manhole

UNDERWRITERS LABORATORIES (UL)

UL 1072	(2006; Reprint Jun 2013) Medium-Voltage Power Cables
UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 44	(2014; Reprint Feb 2015) Thermoset-Insulated Wires and Cables
UL 94	(2013; Reprint Jul 2015) Standard for Tests of Flammability of Plastic Materials for Parts in Devices and Appliances
UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape

UL 514A	(2013) Metallic Outlet Boxes
UL 514B	(2012; Reprint Nov 2014) Conduit, Tubing and Cable Fittings
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 651	(2011; Reprint May 2014) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 83	(2014) Thermoplastic-Insulated Wires and Cables
UL 854	(2004; Reprint Nov 2014) Standard for Service-Entrance Cables

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

1.2 SYSTEM DESCRIPTION

Items provided under this section must be specifically suitable for the following service conditions. Seismic details must conform to UFC 3-310-04 "Seismic Design for Buildings" and UFGS 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT. UFGS 26 08 00 APPARATUS INSPECTION AND TESTING also applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

d. Underground structures subject to aircraft loading are indicated on the drawings.

1.4 SUBMITTALS

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NOTE: If 01 33 29 is incorporated in the specifications, select that option below. If not, select the option for 01 57 19. Include items noted at SD-01 and SD-11 as applicable, based on project scope.
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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the [Sustainability eNotebook, in conformance with Section 01 33 29 SUSTAINABILITY REPORTING][Environmental Records Binder, in conformance to Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS]. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Concrete (Recycled Content); S

SD-02 Shop Drawings

Precast underground structures; G

SD-03 Product Data

Medium voltage cable; G

Medium voltage cable joints; G

Medium voltage cable terminations; G

Precast concrete structures; G

Sealing Material FIO

Pulling-In Irons FIO

Manhole frames and covers; G

Handhole frames and covers; G

Frames and Covers for Airfield Facilities; G

Composite/fiberglass handholes; G

Cable supports (racks, arms and insulators); G

Protective Devices and Coordination Study; G

The study must be submitted with protective device equipment submittals. No time extension or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed must be

based on recommendations of this study. The Government must not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

SD-06 Test Reports

Medium voltage cable qualification and production tests

Field Acceptance Checks and Tests; G

Arc-proofing test for cable fireproofing tape; G

Cable Installation Plan and Procedure; G

One hard copy and one electronic (CD/DVD, as necessary, pdf format (searchable)) copy of the information described below in 8-1/2 by 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Separate sections by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

a. Site layout drawing with cable pulls numerically identified.

b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

c. The cable manufacturer and type of cable.

d. The dates of cable pulls, time of day, and ambient temperature.

e. The length of cable pull and calculated cable pulling tensions.

f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Cable splicer/terminator; G

Cable Installer Qualifications; G

Directional Boring Certificate of Conformance; G

Insulation; G

Concrete; G

SD-11 Closeout Submittals

Concrete (Recycled Content); S

1.5 QUALITY ASSURANCE

1.5.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

a. Material description (i.e. f'c and Fy)

b. Manufacturer's printed assembly and installation instructions

c. Design calculations

d. Reinforcing shop drawings in accordance with ACI SP-66

e. Plans and elevations showing opening and pulling-in iron locations and details

1.5.2 Certificate of Competency for Cable Splicer/Terminator

The cable splicer/terminator must have a certification from the National Cable Splicing Certification Board (NCSCB) or other proof of competency in the field of splicing and terminating shielded medium voltage (5 kV to 35 kV) power cable using pre- manufactured kits (pre-molded, heat-shrink, cold shrink). Submit "Proof of Certification" for approval, for the individuals that will be performing cable splicer and termination work, 30 days before splices or terminations are to be made.

1.5.3 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers. Cable installer must demonstrate experience with a minimum of three medium voltage cable installations. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for an alternate qualified cable installer.

1.5.4 Directional Boring Certificate of Conformance (None In This Task Order)

Provide certification of compliance with the registered Professional

Engineer's design requirements for each directional bore, including: HDPE conduit size and type, bend radius, elevation changes, vertical and horizontal path deviations, conductor size and type and any conductor de-rating due to depth of conduit. Record location and depth of all directional-bore installed HDPE conduits using Global Positioning System (GPS) recording means with "resource grade" accuracy.

1.5.5 Insulation

Submit manufacturer documentation indicating type of recovered materials and the percentage of such material that is recovered, in conformance with Section 01 62 35 RECYCLED/RECOVERED/BIOBASED MATERIALS. Alternately, submit

written justification of non-use per Section 01 62 35 RECYCLED/RECOVERED/BIOBASED MATERIALS.

1.5.6 Concrete (None In This Task Order)

Submit manufacturer documentation indicating type of recovered materials and the percentage of such material that is recovered, in conformance with Section 01 62 35 RECYCLED/RECOVERED/BIOBASED MATERIALS. Alternately, submit written justification of non-use per Section 01 62 35 RECYCLED/RECOVERED/BIOBASED MATERIALS.

1.5.7 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of IEEE C2 and NFPA 70 unless more stringent requirements are specified or indicated.

1.5.8 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size.The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.8.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.8.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 400 volts per mil at 60 Hz, and tensile strength must be minimum 3500 psi.

2.1.2 Intermediate Metal Conduit

UL 1242.

2.1.2.1 Intermediate Metal Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 400 volts per mil at 60 Hz, and tensile strength must be minimum 3500 psi.

2.1.3 Plastic Conduit for Direct Burial

UL 651, Schedule 40 or as indicated. For use on low voltage circuits only.

2.1.4 Plastic Duct for Concrete Encasement

UL 651 and ASTM F512, NEMA TC 2, Type EPC-40-PVC or as indicated.

2.1.5 High Density Polyethylene (HDPE) Electrical Conduit for Directional Boring

Smooth wall, approved/listed for directional boring, minimum Schedule 80, ASTM F2160, NEMA TC 7.

2.1.6 Innerduct

Provide solid wall polyethylene (PE) or PVC innerducts, or fabric-mesh innerducts. Innerducts shall have pull wire. Size as indicated.

2.1.7 Duct Sealant

UL 94, Class HBF. Provide high-expansion urethane foam duct sealant that expands and hardens to form a closed, chemically and water resistant, rigid structure. Sealant must be compatible with common cable and wire jackets and shall be capable of adhering to metals, plastics and concrete. Sealant

must be capable of curing in temperature ranges of 35 degrees F to 95 degrees F. Cured sealant must withstand temperature ranges of -20 degrees F to 200 degrees F without loss of function. Compounds must have no injurious effect upon the hands of workmen or upon materials.

2.1.8 Fittings

2.1.8.1 Metal Fittings

UL 514B.

2.1.8.2 PVC Conduit Fittings

UL 514B, UL 651 or NEMA TC 3 as required.

2.1.8.3 PVC Duct Fittings

NEMA TC 9.

2.1.8.4 Outlet Boxes for Steel Conduit

Outlet boxes for use with rigid or flexible steel conduit must be cast-metal cadmium or zinc-coated if of ferrous metal with gasketed closures and must conform to UL 514A.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors must be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements. Wires and cables manufactured more than 12 months prior to date of delivery to the site are not acceptable. Service entrance conductors must conform to UL 854, type USE.

2.2.1 Conductor Types

Cable and duct sizes indicated are for copper conductors and THHN/THWN unless otherwise noted. Conductors No. 10 AWG and smaller must be solid. Conductors No. 8 AWG and larger must be stranded. All conductors must be copper.

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt, THWN/THHN conforming to UL 83 or Type XHHW conforming to UL 44. Copper conductors must be annealed copper complying with ASTM B3 and ASTM B8.

2.2.3 Jackets

Multi-conductor cables must have an overall PVC outer jacket.

2.2.4 Direct Buried

Single-conductor and multi-conductor cables must be of a type identified for direct burial.

2.2.5 In Duct

Cables must be single-conductor cable. Cables in factory-installed, coilable-plastic-duct assemblies must conform to NEMA TC 7.

2.2.6 Cable Marking

Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout the cable length.

Identify each cable by means of a fiber, laminated plastic, or non-ferrous metal tags, or approved equal, in each manhole, handhole, junction box, and each terminal. Each tag must contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

Conductors must be color coded. Provide conductor identification within each enclosure where a tap, splice, or termination is made. Conductor identification must be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, heat shrink type sleeves, or colored electrical tape. Control circuit terminations must be properly identified. Color must be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals must be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems must be as follows:

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

b. 480/277 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

d. On three-phase, four-wire delta system, high leg must be orange, as required by NFPA 70.

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

a. For use with copper conductors: UL 486A-486B.

2.4 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material applied in accordance with the manufacturer's written instructions.

2.4.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation must not require heat or flame, or any additional materials such as covering or adhesive. It must be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.5 MEDIUM VOLTAGE CABLE

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (Kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than 12 months prior to date of delivery to the site are not acceptable. Provide single conductor type cables unless otherwise indicated.

2.5.1 Cable Configuration

Provide Type MV-105 cable, conforming to NEMA WC 74/ICEA S-93-639 and UL 1072. Provide cables manufactured for use in duct applications. Cable must be rated 15 kV with 133 percent insulation level.

2.5.2 Conductor Material

Provide soft drawn copper cables complying with ASTM B3 and ASTM B8 for regular concentric and compressed stranding or ASTM B496 for compact stranding.

2.5.3 Insulation

Provide ethylene-propylene-rubber (EPR) insulation conforming to the requirements of ANSI/NEMA WC 71/ICEA S-96-659 and AEIC CS8. Conform with the requirements in Section 01 62 35 RECYCLED/RECOVERED/BIOBASED MATERIALS.

2.5.4 Shielding

Cables rated for 2 kV and above must have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper tape shield for each phase.

2.5.5 Neutrals (No Medium Voltage Neutrals On JBLM's System)

Neutral conductors must be copper, employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable.

2.5.6 Jackets

Provide cables with a PVC or polyethylene jacket.

2.6 MEDIUM VOLTAGE CABLE TERMINATIONS

IEEE 48 Class 1; of the molded elastomer, pre-stretched elastomer, or heat-shrinkable elastomer. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber (EPR) or ethylene propylene diene monomer (EPDM). Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations, where required, must be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Terminations must be provided in a kit, including: skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations must be the product of one manufacturer, suitable for the type, diameter,

insulation class and level, and materials of the cable terminated. Do not use separate parts of copper or copper alloy in contact with aluminum alloy parts in the construction or installation of the terminator.

2.6.1 Cold-Shrink Type

Terminator must be a one-piece design, utilizing the manufacturer's latest technology, where high-dielectric constant (capacitive) stress control is integrated within a skirted insulator made of silicone rubber. Termination must not require heat or flame for installation. Termination kit must contain all necessary materials (except for the lugs). Termination must be designed for installation in low or highly contaminated indoor or outdoor locations, and must resist ultraviolet rays and oxidative decomposition.

2.6.2 Heat Shrinkable Type

Terminator must consist of a uniform cross section heat shrinkable polymeric construction stress relief tubing and environmentally sealed outer covering that is non-tracking, resists heavy atmospheric contaminants, ultra violet rays and oxidative decomposition. Provide heat shrinkable sheds or skirts of the same material. Termination must be designed for installation in low or highly contaminated indoor or outdoor locations.

2.6.3 Separable Insulated Connector Type (200Amp Loadbreak Elbows & 600 Amp Deadbreak Elbows)

IEEE 386. Provide connector with steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material. Provide connectors of the load-break or dead-break type as indicated, of suitable construction for the application and the type of cable connected, and that include cable shield adaptors. Provide external clamping points and test points. Separable connectors must not be used in manholes/handholes.

a. 200 Ampere load-break connector ratings: Voltage: 15 kV, 95 kV BIL, unless indicated otherwise. Short time rating: 10,000 rms symmetrical amperes.

b. 600 Ampere dead-break connector ratings: Voltage: 15 kV, 95 kV BIL, unless indicated otherwise. Short time rating: 25,000 rms symmetrical amperes. Connectors must have 200 ampere bushing interface for surge arresters as indicated in the Task Order.

2.7 MEDIUM VOLTAGE CABLE JOINTS (PW Does Not Allow Splicing Cable)

Provide joints (splices) in accordance with IEEE 404 suitable for the rated voltage, insulation level, insulation type, and construction of the cable. Joints must be certified by the manufacturer for waterproof, submersible applications. Upon request, supply manufacturer's design qualification test report in accordance with IEEE 404. Connectors for joint must be tin-plated electrolytic copper, having ends tapered and having center stops to equalize

cable insertion.

2.7.1 Heat-Shrinkable Joint

Heat shrinkable joints shall consist of uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductor layer for shielding. Replace original cable jacket with a heavy-wall heat-shrinkable sleeve with hot-melt adhesive coating.

2.7.2 Cold-Shrink Rubber-Type Joint

Joint must be of a cold shrink design that does not require any heat source for its installation. Splice insulation and jacket must be of a one-piece factory formed cold shrink sleeve made of black EDPM rubber. Splice must be packaged three splices per kit, including complete installation instructions.

2.8 TAPE

2.8.1 Insulating Tape

UL 510, plastic insulating tape, 10-mil (min) thick, capable of performing in a continuous temperature environment of 80 degrees C.

2.8.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Sections 31 23 00.00 20 EXCAVATION AND FILL and 31 00 00 EARTHWORK.

2.8.3 Fireproofing Tape

Provide tape composed of a flexible conformable unsupported intumescent elastomer. Tape must be not less than .030 inch thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, and must not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus. Cable fireproofing systems shall have passed Con-Ed EO 5343-14 Flammability Test for application on the type of medium-voltage cables provided.

Asbestos materials are not acceptable.

2.9 PULL ROPE

Plastic or flat pull line having a minimum tensile strength of 200 pounds.

2.10 GROUNDING AND BONDING

2.10.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used for rods 20 feet or longer.

2.10.2 Grounding Conductors

Stranded-bare copper conductors must conform to ASTM B8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors must conform to ASTM B1 for sizes No. 8 and smaller. Insulated conductors must be of the same material as phase conductors and green color-coded, except that conductors must be rated no more than 600 volts. Aluminum is not acceptable.

2.11 CAST-IN-PLACE CONCRETE

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NOTE: If 01 33 29 is incorporated in the specifications, select that option below. If not, select the option for 01 57 19.
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NOTE: Ground granulated blast furnace slag is likely more aligned with reduced life cycle impact criteria for environmentally preferable purchasing than are coal derivatives such as fly ash, silica fume, or cenospheres.
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Provide concrete for encasement of underground ducts with 3000 psi minimum 28-day compressive strength. Provide reinforcement where required in IEEE C2 or as indicated in the Task Order. Controlled Density Fill (CDF) mix design shall meet the requirements of WSDOT Section 2-09.3(1)E. Concrete associated with electrical work for other than encasement of underground ducts must be 4000 psi minimum 28-day compressive strength unless specified otherwise.

Provide products and documentation in accordance with Section [01 33 29 SUSTAINABILITY REPORTING][01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS] paragraph RECYCLED MATERIALS. For more information see https://sftool.gov/greenprocurement/green-products/1/construction-materials/29/cement-concrete/0?addon=False and https://www.epa.gov/smm/comprehensive-procurement-guideline-cpg-program.

2.12 UNDERGROUND STRUCTURES

Provide precast concrete underground structures as indicated, conforming to ASTM C857, ASTM C478, and IEEE C2. Top, walls, and bottom must consist of reinforced concrete. Walls and bottom must be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking and training. Covers must fit the frames without undue play. Form steel and iron to shape and size with sharp

lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Pulling-in irons and other built-in items shall be set in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, must be adequate to accommodate the cable.

2.12.1 Precast Concrete Structures, Risers and Tops

Precast concrete underground structures must be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes. Structures must be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face. The minimum design vertical load must be for H20 highway loading per AASHTO HB-17.

2.12.1.1 Construction

Structure top, bottom, and wall must be of a uniform thickness of not less than 6 inches. Thin-walled knock-out panels for designed or future duct bank entrances are not permitted. Provide quantity, size, and location of duct bank entrance windows as directed, and cast completely open by the pre-caster. Size of windows must exceed the nominal duct bank envelope dimensions by at least 12 inches vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows must be a minimum of 6 inches from the inside surface of adjacent walls, floors, or ceilings. The perimeter of precast window openings shall be formed to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. Provide drain sumps a minimum of 12 inches in diameter and 4 inches deep for precast structures.

2.12.1.2 Joints

Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to ASTM C990. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

2.12.2 Manhole Frames and Covers

Unless directed otherwise, provide cast iron frames and covers for manholes conforming to CID A-A-60005. Cast the words "ELECTRIC" or "TELECOMMUNICATIONS" in the top face of power and telecommunications manhole

covers, respectively.

2.12.3 Composite/Fiberglass Handholes and Covers

Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass conforming to ANSI/SCTE 77. Unless indicated otherwise, these handholes can only be used for low voltage cables installed in parking lots, sidewalks, and turfed areas.

2.13 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

The metal portion of racks and arms must be Hot Dip Galvanizes per ASTM A123 / A-153 after fabrication.

2.13.1 Cable Rack Stanchions

The wall bracket or stanchion must be 1-1/2” inches by approximately 9/16 inch by 3/16 inch channel steel, or 4 inches by approximately 1 inch glass-reinforced nylon with recessed bolt mounting holes, 48 inches long (minimum) in manholes.

2.13.2 Rack Arms

Cable rack arms must be steel or malleable iron or glass reinforced nylon and must be of the removable type. Rack arm length must be a minimum of 8 inches and a maximum of 12 inches.

2.13.3 Insulators

Insulators for metal rack arms must be dry-process glazed porcelain. Insulators are not required for nylon arms.

2.14 CABLE TAGS IN MANHOLES

Provide tags for each power cable located in manholes. The tags must be polyethylene. Do not provide handwritten letters. Naming convention for cable tags shall conform to JBLM standards.

2.14.1 Polyethylene Cable Tags

Provide tags of phenolic plastic that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties must have a minimum loop tensile strength of 125 pounds. The cable tags must have White letters, numbers, and symbols 3/8” high on a Black background. Letters, numbers, and symbols must not fall off or change positions regardless of the cable tags' orientation.

2.15 MEDIUM VOLTAGE ABOVE GROUND CABLE TERMINATING CABINETS

Cable terminating cabinets must be hook-stick operable, dead-front construction conforming to the requirements of IEEE C37.20.3, Category A. Provide cabinets with 200 A load-break junctions and elbow-type separable load-break connectors, cable parking stands, and grounding lugs; or 600 A dead-break junctions and elbow-type separable dead-break connectors, cable parking stands, and grounding lugs, as indicated in the Task Order. Provide cable terminating equipment in conformance with IEEE 386.

Ratings at 60 Hz must be:

Nominal voltage (kV)	13.8
Rated maximum voltage (kV)	15
Rated continuous current (A)	200 or 600 as indicated
One-second short-time current-carrying capacity (kA)	16
BIL (kV)	95

2.16 SOURCE QUALITY CONTROL

2.16.1 Arc-Proofing Test for Cable Fireproofing Tape

Manufacturer must test one sample assembly consisting of a straight lead tube 12 inches long with a 2-1/2 inch outside diameter, and a 1/8 inch thick wall, and covered with one-half lap layer of arc and fireproofing tape per manufacturer's instructions. The arc and fireproofing tape must withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of 13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode must be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. The arc must be directed toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Each sample assembly must be tested at three unrelated points. Start time for tests must be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time must be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube.Submittals for arc-proofing tape must indicate that the test has been performed and passed by the manufacturer. Compliance with Con-Ed Test EO-5343-14 meets these requirements.

2.16.2 Medium Voltage Cable Qualification and Production Tests

Provide results of AEIC CS8 qualification and production tests as applicable for each type of medium voltage cable.

2.17 PROTECTIVE DEVICES AND COORDINATION

Provide protective devices and coordination as specified in the Task Order.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70 and IEEE C2 as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758 and (RUS Bull 1751F-644.

3.2 CABLE INSPECTION

Inspect each cable reel for correct storage positions, signs of physical damage, and broken end seals prior to installation. If end seal is broken, remove moisture from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE

Obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure. Perform pulling calculations and prepare a pulling plan and submit along with the manufacturer's instructions in accordance with SUBMITTALS. Install cable strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

Calculations and pulling plan must include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls.

f. Cable percentage conduit fill.

g. Cable sidewall bearing pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

3.4 UNDERGROUND SECONDARY FEEDERS SUPPLYING BUILDINGS

Cables shall be extended into the various buildings and shall be connected to the first applicable termination point in each building as indicated. Interfacing with building interior conduit systems shall be at conduit stubouts terminating 5 feet outside of a building and 2 feet below finished grade as indicated in the Task Order. After installation of cables, conduits shall be sealed with caulking compound to prevent entrance of moisture or gases into buildings.

3.5 UNDERGROUND STRUCTURE CONSTRUCTION

Provide standard type or precast construction as specified herein. Horizontal concrete surfaces of floors must have a smooth trowel finish. Locate duct entrances and windows in the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground structures must fit the frames without undue play.Steel and iron must be formed to shape and size with sharp lines and angles.Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Due to subsurface conditions, normal drainage and other underground conditions, manhole locations, as indicated, are approximate. Coordinate exact manhole locations with other utilities and finished grading and paving. In paved areas, the top of manhole covers shall be 1/4 inch above the finished paved surface and shall be approved for vehicular loads. In unpaved areas, the top of the manhole/handhole covers shall be approximately 1/2 inch above surrounding grade. Locations shall be approved by Contracting Officer prior to installation.

3.5.1 Precast Concrete Construction

Unless directed otherwise, set commercial precast structures on 6 inches of level, 90 percent compacted granular fill, 3/4 inch to 1 inch size, extending 12 inches beyond the structure on each side. Granular fill shall be compacted a minimum of four passes with a plate type vibrator. Installation must additionally conform to the manufacturer's instructions.

3.5.2 Pulling-In Irons

Provide steel bars bent as indicated, and cast in the walls and floors. Alternatively, pipe sleeves may be precast into the walls and floors where required to accept U-bolts or other types of pulling-in devices possessing the strengths and clearances stated herein. The final installation of pulling-in devices must be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor the irons must be a minimum of 6 inches from the edge of the sump, and in the walls the irons must be located within 6 inches of the projected center of the duct bank pattern or precast window in the opposite wall. However, the pulling-in iron must not be located within 6 inches of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 6 inch clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 3 foot length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner must be positioned directly in line with, or when not possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of 3 inches from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons must have a clear projection into the structure of approximately 4 inches and must be designed to withstand a minimum pulling-in load of 6000 pounds. Irons must be hot-dipped galvanized after fabrication.

3.5.3 Cable Racks, Arms and Insulators

Cable racks, arms and insulators must be sufficient to accommodate the cables. Space racks in power manholes not more than 3 feet apart, and provide each manhole wall with a minimum of two racks. Space racks in signal manholes not more than 16-1/2 inches apart with the end rack being no further than 12 inches from the adjacent wall. Methods of anchoring cable racks must be as follows:

a. Provide a 5/8 inch diameter by 5 inch long anchor bolt with 3 inch foot cast in structure wall with 2 inch protrusion of threaded portion of bolt into structure. Provide 5/8 inch steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.

b. Provide concrete channel insert with a minimum load rating of 800 pounds per foot. Insert channel must be steel;" channel insert must be cast flush in structure wall.

c. Provide concrete "spot insert" at each anchor bolt location, cast flush in structure wall. Each insert must have minimum 800 pound load rating. Provide 5/8 inch diameter by 3 inch long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing bolts.

3.5.4 Field Painting

Cast-iron frames and covers not buried in concrete or masonry must be cleaned of mortar, rust, grease, dirt and other deleterious materials, and given a coat of bituminous paint.

3.5.5 Communications Manholes

The number of hot-dip galvanized cable racks with a plastic coating over the galvanizing indicated shall be installed in each telephone manhole. Each cable rack shall be provided with 2 cable hooks. Cables for the telephone and communication systems will be installed by others.

Due to subsurface conditions, normal drainage, or other underground conditions, manholes shall be approved by the Contracting Officer prior to installation. The Contractor shall obtain the permanent manhole number from the Contracting Officer and all drawings shall be annotated showing the assigned number. In paved areas, the top of manhole covers shall be 1/4 inch above the finished paved surface and shall be approved for vehicular loads. In unpaved areas, the top of the manhole/handhole covers shall be approximately 1/2 inch above surrounding grade. One 6 inch and two 12 inch risers shall be installed between the top of the manhole and the manhole frame to elevate the manhole cover to grade. Manholes shall be placed with a minimum of 36 inch cover above the manhole structure.

3.6 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.6.1 Requirements

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Unless indicated otherwise in the Task Order, provide a spare 2" control duct with each MV duct bank. Provide metallic warning tape above ducts and locate 12" below finished grade. Provide a minimum 1/0 AWG bare copper ground wire for 200 amp and below feeders and laterals, and a minimum 4/0 AWG bare copper ground wire for 600 amp feeders. Bare copper ground wire shall be embedded in the encasement, and shall be bonded to ground rings (loops) in all manholes/handholes and to ground rings (loops) at all equipment slabs (pads) and at all entrance facilities. Ducts must have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 2 inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius must be 18 inches for ducts of less than 3 inch diameter, and 36 inches for ducts 3 inches or greater in diameter. Otherwise, long sweep bends having a minimum radius of 25 feet must be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used must be 30 degrees and manufactured bends must be used. Provide ducts with

end bells whenever duct lines terminate in structures.

3.6.2 Treatment

Ducts must be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers must be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer must be used whenever an existing duct is connected to a duct of different material or shape. Ducts must be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts must be thoroughly cleaned before being laid. Plastic ducts must be stored on a flat surface and protected from the direct rays of the sun.

3.6.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 3 inches and larger, draw a flexible testing mandrel approximately 12 inches long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than 3 inches, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.6.4 Jacking and Drilling Under Roads and Structures

Where indicated, conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, must be zinc-coated, rigid steel, jacked into place. Where ducts are jacked under existing pavement, rigid steel conduit must be installed because of its strength. To protect the corrosion-resistant conduit coating, pre-drilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 50 feet in length, the pre-drilling method or the jack-and-sleeve method will be used. Separators or spacing blocks must be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 4 feet on centers. Hydraulic jet method must not be used.

3.6.5 Galvanized Conduit Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) in wet locations must be PVC coated and must extend from at least 2 inches within the concrete to the first coupling or fitting outside the concrete (minimum of 6 inches from penetration).

3.6.6 Multiple Conduits

Separate multiple conduits by a minimum distance of 3 inches. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to

strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly must consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

3.6.7 Conduit Plugs and Pull Rope

New conduit indicated as being unused or empty must be provided with plugs on each end. Plugs must contain a weep hole or screen to allow water drainage. Provide a plastic pull rope having 3 feet of slack at each end of unused or empty conduits.

3.6.8 Conduit and Duct Without Concrete Encasement

Conduit(s) for low voltage circuits may be direct buried (i.e. without concrete encasement) where indicated in the Task Order. Depths to top of the conduit must be not less than 36 inches below finished grade. Provide not less than 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 3 inches, fill and tamp level with original bottom with sand or earth free from particles that would be retained on a 1/4 inch sieve. The first 6 inch layer of backfill cover must be sand compacted as previously specified. The rest of the excavation must be backfilled and compacted in 3 to 6 inch layers. Provide color, type and depth of warning tape as specified in Section 31 23 00.00 20 EXCAVATION AND FILL and 31 00 00 EARTHWORK.

3.6.8.1 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 3 inch concrete cover around ducts. Concrete encasement must extend at least 5 feet beyond the edges of paved areas and roads, and 12 feet beyond the rails on each side of railroad tracks. Depths to top of the concrete envelope must be not less than 36 inches below finished grade, and under railroad tracks not less than 50 inches below the top of the rails. Provide reinforcement in concrete for roadway, airfield and railroad crossings.

3.6.8.2 Directional Boring

HDPE conduits must be installed below the frost line and as specified herein.

For feeder and branch circuit wiring less than 600 volts, depths to the top of the conduit must not be less than 36 inches in pavement- or non-pavement-covered areas.

3.6.9 Duct Encased in Concrete

All primary duct banks shall be encased in Controlled Density Fill (CDF), except 3000 psi concrete shall be used under roads or paved areas subject to vehicular traffic. Depths to top of the concrete envelope shall not be less than 18 inches below finished grade, except under roads and pavement concrete envelope must not be less than 36 inches below finished grade, and under railroad tracks not less than 50 inches below the top of the rails. Do not mix different kinds of conduit in any one duct bank. Concrete encasement must be rectangular in cross-section and must provide at least 3 inches of concrete cover for ducts. Separate conduits be a minimum concrete thickness of 3 inches and as required by IEEE C2. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring must be done by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly. Provide steel reinforcing in the concrete envelope where indicated in the Task Order or as required elsewhere. Provide color, type and depth of warning tape as specified in Section 31 23 00.00 20 EXCAVATION AND FILL and 31 00 00 EARTHWORK.

3.6.9.1 Connections to Manholes

Duct bank envelopes connecting to underground structures must be flared to have enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section must be larger than the corresponding manhole opening dimensions by no less than 12 inches in each direction. Perimeter of the duct bank opening in the underground structure must be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal between the envelope and the wall of the structure.

3.6.9.2 Connections to Existing Underground Structures

For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve steel in the structure wall. Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

3.6.9.3 Connections to Existing Concrete Pads

For duct bank connections to concrete pads, break an opening in the pad out to the dimensions required and preserve steel in pad. Cut the steel and extend into the duct bank envelope. Chip out the opening in the pad to form a key for the duct bank envelope.

3.6.9.4 Connections to Existing Ducts

Where connections to existing duct banks are indicated, excavate the banks to the maximum depth necessary. Cut off the banks and remove loose concrete from the conduits before new concrete-encased ducts are installed. Provide a reinforced concrete collar, poured monolithically with the new duct bank, to take the shear at the joint of the duct banks. Remove existing cables

which constitute interference with the work. Unless indicated otherwise, abandon in place those ducts and cables no longer used where they do not interfere with the work.

3.6.9.5 Partially Completed Duct Banks

During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud, and, and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 2 feet back into the envelope and a minimum of 2 feet beyond the end of the envelope. Provide one No. 4 bar in each corner, 3 inches from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately one foot apart.Restrain reinforcing assembly from moving during concrete pouring.

3.6.9.6 Removal of Ducts

Where duct lines are removed from existing underground structures, close the openings to waterproof the structure. Chip out the wall opening to provide a key for the new section of wall.

3.6.10 Duct Sealing

Seal all electrical penetrations for radon mitigation, maintaining integrity of the vapor barrier, and to prevent infiltration of air, water, insects and vermin.

3.7 CABLE PULLING

Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables. Pull in cable from live vault when applicable, toward vault that has no existing energized cable in it. Otherwise pull in direction with the lowest calculated pulling tensions and lowest calculated side wall pressure. Do not exceed manufacturer's recommendations for cable pulling tension and side wall pressure. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turn-ups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape or wire shield must have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.7.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.8 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum spare cable lengths. A minimum of 360° loop of cable shall be left in each vault. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. (Support cable splices in underground structures by racks on each side of the splice PW does not allow splices except with junctions.).
Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide two spare three-insulator rack arms for each cable rack in each underground structure.

3.8.1 Cable Tag Installation

Install cable tags in each manhole. Tag wire and cable provided by this contract. Install cable tags over the fireproofing, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes.

3.9 CONDUCTORS INSTALLED IN PARALLEL

Conductors must be grouped such that each conduit of a parallel run contains 1 Phase A conductor, 1 Phase B conductor and 1 Phase C conductor for 3-Phase power.

3.10 LOW VOLTAGE CABLE SPLICING AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified in the Task Order, and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. Make splices in underground distribution systems only in accessible locations such as manholes, handholes, or aboveground termination pedestals.

3.11 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

3.12 MEDIUM VOLTAGE CABLE JOINTS

Provide power cable joints (splices) suitable for continuous immersion in water. Make joints only in accessible locations in manholes or handholes by using materials and methods in accordance with the written instructions of the joint kit manufacturer. Medium voltage cable joints shall only be made by qualified cable splicers only.

3.12.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice. Provide a bare copper or tinned copper ground connection brought out in a watertight manner and grounded to the manhole grounding loop as part of the splice installation. Ground conductors, connections, and rods must be as specified elsewhere in this section. Wire must be trained to the sides of the enclosure to prevent interference with the working area.

3.13 CABLE END CAPS

Cable ends must be sealed at all times with coated heat shrinkable end caps. Cables ends must be sealed when the cable is delivered to the job site,

while the cable is stored and during installation of the cable. The caps must remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.14 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in underground structures. Medium voltage cable and conductors shall be fire-proofed for their entire length in underground structures. Where cables or conductors have been lubricated to enhance pulling into ducts, the lubricant shall be removed from cables and conductors exposed in underground structures before fire-proofing.

3.14.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

3.14.2 Tape-Wrap

Metallic-sheathed or metallic armored cables without a nonmetallic protective covering shall be tape wrapped over the sheath or armor prior to application of fireproofing. Wrap must be in the form of two tightly applied half-lapped layers of a pressure-sensitive 10 mil thick plastic tape, and must extend not less than one inch into the duct. Even out irregularities of the cable, such as at splices, with insulation putty before applying tape.

3.15 GROUNDING SYSTEMS

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms or as indicated in the Task Order. A ground mat or ring consisting of bare copper conductors and/or driven ground rods shall be installed under or around pad-mounted equipment as indicated in the Task Order. Equipment frames of metal-enclosed equipment, and other noncurrent-carrying metal parts, such as cable shields, cable sheaths and armor, and metallic conduit shall be grounded. At least 2 connections shall be provided from each transformer, switchgear ground bus, and/or unit substation to the ground mat or ring.

3.15.1 Grounding Electrodes

Grounding electrodes shall be installed as shown and indicated in the Task Order. Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

a. Driven Ground Rods - Unless otherwise indicated, cone pointed driven ground rods shall be driven into the earth full depth plus 12 inches, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.

b. Ground mat - A ground mat shall be installed as shown consisting of bare copper conductors installed 36 inches, plus or minus 3 inches, below the finished grade. Mat conductors shall be bonded to all other grounding electrodes as indicated. Mat conductors shall be sized as indicated.

c. Ground ring - A ground ring shall be installed as shown consisting of bare copper conductors installed not less than 30 inches below finished grade. Ground ring conductors shall be sized as indicated.

d. Additional electrodes - When the required ground resistance is not met, additional electrodes shall be provided interconnected with grounding conductors to achieve the specified ground resistance. The additional electrodes will be up to three (3) 10 foot rods spaced a minimum of 10 feet apart or a single extension-type rod, 3/4 inch diameter, up to 30 feet long. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately.

3.15.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds that are "puffed up" or that show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make compression connections using a minimum 12 ton hydraulic compression tool to provide the correct circumferential pressure. Tools and dies must be as recommended by the manufacturer. An embossing die code or other standard method must provide visible indication that a connector has been adequately compressed on the ground wire.

3.15.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.15.4 Ground Cable Crossing Expansion Joints

Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

3.15.5 Manhole Grounding

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately 12 inches below vault lid. Secure the conductor to the manhole walls at intervals not exceeding 36 inches. Provide a manhole/handhole/concrete pull box grounding electrode (driven ground rod) in each underground structure. Driven ground rods shall be protected by a double wrapping of pressure-sensitive plastic tape for a distance of 2 inches above and 6 inches below concrete penetrations. Connect the conductor to the manhole grounding electrode with 4/0 AWG conductor. Connect all incoming 4/0 grounding conductors to the ground loop adjacent to the point of entry into the manhole. Bond the ground loop to all cable shields, metal cable racks, cable pulling irons and other metal equipment with a minimum 4 AWG conductor.

3.15.6 Surge Arrestor Grounding

Surge arresters and neutrals shall be bonded directly to the transformer enclosure and then to the grounding electrode system with a bare copper conductor, sized as shown. Lead lengths shall be kept as short as practicable but long enough to freely remove elbow arrester with insulated clamp stick (shotgun), with no kinks or sharp bends in grounding electrode.

3.15.7 Riser Pole Grounding

A single continuous vertical grounding electrode conductor shall be installed on each riser pole and connected directly to the grounding electrodes indicated on the drawings or required by these specifications. All equipment, neutrals, surge arresters, and items required to be grounded shall be connected directly to this vertical conductor. The grounding electrode conductor shall be sized as shown. Grounding electrode conductors shall be stapled to wood poles at intervals not exceeding 2 feet.

3.15.8 Fence Grounding

Provide grounding for fences as indicated in accordance in contract drawings or as required by IEEE C2 or NFPA 70.

3.16 CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS

Connections between aerial and underground systems shall be made as follows. Underground cables shall be extended up poles in conduit to cable

terminations. For conduits 1-1/4” and smaller, Conduits shall be secured to the poles by 2-hole galvanized steel pipe straps spaced at not more than 10 feet apart with 1 strap not more than 12 inches from any bend or termination. Standoff brackets shall be used for conduit 1-1/2” and larger with 5” minimum space between conduit and pole. Standoff brackets may be below grade for temporary support and shall not less than 7’ above finish grade, not more than 10’ apart and not less than 12” from end of duct. Cable guards shall be secured to poles in accordance with the manufacturer's published procedures. Conduits shall be equipped with bushings to protect cables and minimize water entry. Sealed, skirted cold shrink or heat shrink terminations shall be used to terminate medium-voltage multiple-conductor cable. Cables shall be supported by devices separate from the conduit or guard, near their point of exit from the conduit or guard. Pole installation shall be in accordance with Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

3.17 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70, Sections 31 23 00.00 20 EXCAVATION AND FILL and 31 00 00 EARTHWORK.

3.18 CAST-IN-PLACE CONCRETE

Provide concrete with a minimum compressive strength of 3,000 psi and conforming to Task Order requirements. Where indicated, provide reinforcement.

3.18.1 Concrete Slabs for Equipment

Unless otherwise indicated, the slab must be at least 6 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 3 inches from the top of the slab. Slabs may be either poured-in-place or pre-fabricated. Slab must be placed on a 6 inch thick, well-compacted gravel base. Top of concrete slab must be approximately 4 inches above finished grade with gradual slope for drainage. Edges above grade must have 3/4 inch chamfer. Slab must be of adequate size to project at least 8 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Conduits shall be installed prior to placing pads. Where grounding electrode conductors are installed through pads, PVC conduit sleeves shall be installed through the concrete to provide physical protection. Coordinate dimensions of cable wells with transformer cable training areas. Upon completion of equipment installation, the rectangular hole(s) shall be filled with masonry grout.

3.18.2 Sealing

When the installation is complete, seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals must be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.19 FIELD QUALITY CONTROL

3.19.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.19.1.1 Medium Voltage Cables

Perform tests after installation of cable, splices, and terminators and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Inspect for proper shield grounding, cable support, and cable termination.

(4) Verify that cable bends are not less than ICEA or manufacturer's minimum allowable bending radius. Including during installation.

(5) Inspect for proper fireproofing.

(6) Visually inspect jacket and insulation condition.

(7) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform a shield continuity test on each power cable by ohmmeter method. Record ohmic value, resistance values in excess of 10

ohms per 1000 feet of cable must be investigated and justified.

(2) Perform acceptance test on new cables before the new cables are connected to existing cables and placed into service, including terminations and joints. Perform test on complete new cable system including terminations, and joints. Tests must be very low frequency (VLF) Hipot using alternating voltage-withstand tests in accordance with IEEE 400.2. VLF test frequency must be 0.05 Hz minimum for 60 minutes using a sinusoidal waveform. Test voltages must be as follows:

CABLE RATING	AC TEST VOLTAGE for ACCEPTANCE TESTING
5 kV	10kV rms(peak)
8 kV	13kV rms(peak)
15 kV	20kV rms(peak)

CABLE RATING	AC TEST VOLTAGE for MAINTENANCE TESTING
5 kV	7kV rms(peak)
8 kV	10kV rms(peak)
15 kV	16kV rms(peak)

3.19.1.2 Low Voltage Cables, 600-Volt

Perform tests after installation of cable, splices and terminations and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Verify tightness of accessible bolted electrical connections.

(4) Inspect compression-applied connectors for correct cable match and indentation.

(5) Visually inspect jacket and insulation condition.

(6) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform insulation resistance tests (Megger test) on wiring No. 6

AWG and larger diameter using instrument which applies voltage of approximately 1000 volts dc for one minute.

(2) Perform continuity tests to insure correct cable connection.

3.19.1.3 Grounding System

a. Visual and mechanical inspection. Inspect ground system for compliance with contract plans and specifications. All below grade connections shall be visually inspected, prior to backfilling, by the Contracting Officer or their Representative. Notify the Contracting Officer at least 72 hours before the site is ready to schedule.

b. Electrical tests. Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable megohmmeter tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument must be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test. Provide a site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

3.19.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer must be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --