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USACE / NAVFAC / AFCESA / NASA **UFGS-26 05 13.00 40 (August 2010)**

Preparing Activity: NASA **Superseding UFGS-26 05 13.00 40 (November 2008)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2011
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SECTION 26 05 13.00 40

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08/10

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SECTION 26 05 13.00 40

MEDIUM-VOLTAGE CABLES
08/10

****
NOTE: This guide specification covers the requirements for medium voltage cables, including shielded and nonshielded single-and multiple-conductor power cables, portable cables, cable splices and terminations, single- and multiple-conductor potheads, and fireproofing cables in manholes and utility tunnels.

Show plan layout of power cable and power-cable terminations on drawings. Show size, type, electrical characteristics, and raceway system of power cables and type of cable termination on electrical riser diagrams.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****

PART 1 GENERAL

1.1 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in

this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text are automatically deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

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.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC C8	(2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV
AEIC CS1	(1990e11) Impregnated-Paper-Insulated, Metallic Sheathed Cable, Solid Type

ASTM INTERNATIONAL (ASTM)

ASTM B3	(2001; R 2007) Standard Specification for Soft or Annealed Copper Wire
ASTM D 746	(2007) Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 383	(2003; R 2008) Standard for Qualifying Class 1E Electric Cables and, Field Splices for Nuclear Power Generating Stations 2004
IEEE 400.2	(2004) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

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 WC 2 (1980; Rev 1 1989; R 1998; R 2005) Standard for Steel Armor and Associated Coverings for Impregnated Paper Insulated Cables (ICEA S-67-401 5th Edition)

NEMA WC 27500 (2005) Standard for Aerospace and Industrial Electrical Cable

NEMA WC 70 (2009) Power Cable Rated 2000 V or Less for the Distribution of Electrical Energy--S95-658

NEMA WC 74/ICEA S-93-639 (2006) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2011; TIA 11-1; Errata 2011) National Electrical Code

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-228 (2000) Cable and Wire, Insulated; Methods of Testing

1.2 DEFINITIONS

Medium voltage power cables includes all cables rated above 600 to 35,000 volts.

1.3 GENERAL REQUIREMENTS

****

NOTE: If Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS is not included in the project specification, insert applicable requirements therefrom and delete the following paragraph.

****

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

Provide Certificates for the following showing that the cable manufacturer has made factory-conducted tests on each shipping length of cable. Provide certified copies of test data that shows conformance with the referenced standards and is approved prior to delivery of cable.

1.4 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Keep submittals to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some

submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, use a code of up to three characters within the submittal tags following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that reviews the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Provide equipment and performance data and manufacturer's catalog data for the following items:

Multiple-Conductor Shielded Cables

Multiple-Conductor Nonshielded Cables

Single-Conductor Shielded Cables

Single-Conductor Nonshielded Cables

Portable Cables

Nonmetallic Jacket

SD-06 Test Reports

Provide test reports for the following in accordance with the paragraph entitled, "Field Testing," of this section.

Dielectric Absorption Tests

High-Voltage Tests

Radiographic Tests

SD-07 Certificates

Provide listing of products installed showing qualifications of Cable Splicers to the Contracting Officer prior to specified work.

Provide Certificates for the following:

Lead Sheath

Flammability

Minimum Bending Radius

High-Voltage Tests

Dielectric Absorption Tests

Cable Splicers

SD-08 Manufacturer's Instructions

Provide manufacturer's instructions showing the recommended sequence and method of installation for the following:

Medium-Voltage Power Cables

High-Voltage Power Cables

Pothead Terminations

1.5 PREDICTIVE TESTING AND INSPECTION TECHNOLOGY REQUIREMENTS

****
NOTE: The Predictive Testing and Inspection (PT&I) tests prescribed in section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS are MANDATORY for all [NASA] [_____] assets and systems identified as Critical, Configured, or Mission Essential. If the system is non-critical, non-configured, and not mission essential, use sound engineering discretion to assess the value of adding these additional test and acceptance requirements. See Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS for additional information regarding cost feasibility of PT&I.
****

This section contains systems and/or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems installed by the Contractor have been installed properly and contain no identifiable defects that shorten the design life of a system and/or its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work.

Perform PT&I tests and provide submittals as specified in Section

01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

1.6 QUALIFICATIONS

Cable splicers performing splicing are required to have [5] [_____] years experience in cable splicing and terminations. Once a termination or splice has been started by a worker, the same person completes that particular splice. Start and complete each termination and splice in one continuous work period.

1.7 CABLE VOLTAGE RATINGS

Provide Medium-voltage power cables including multiple- and single-conductor cables rated as follows, phase-to-phase, for grounded and ungrounded neutral systems:

Use cables rated [5,000] [15,000] volts, ungrounded neutral, on [2,400/4,160] [13,200/13,800] [12,470]-volt, three-phase, 60-hertz distribution systems.

1.8 SHIPMENT

Ship cables on reels such that the cable is protected from mechanical injury. Hermetically seal and securely attach each end of each length of cable to the reel.

Make minimum reel drum diameter [14] [_____] times the overall diameter of the cable. Provide a pulling eye that is installed by the manufacturer for each length of cable supplied for installation in ducts, manholes, and utility tunnels.

PART 2 PRODUCTS

2.1 CONDUCTORS

Provide conductors that are solid copper conforming to ASTM B3.

2.2 CABLE IDENTIFICATION

Provide cables that have a tape placed immediately under the lead sheath or outer jacket showing the name of the manufacturer, the year in which the cable was manufactured, and a unique number for identification purposes. Closely group information on the tape at 300 millimeter 1-foot intervals to permit complete identification.

2.3 FLAMMABILITY

Test cables not to be enclosed in metallic conduit for flammability in accordance with [FED-STD-228, Method 5221 [vertical], [spark]][IEEE 383, 20000 watt 70,000 Btu per hour per hour vertical tray flame test].

2.4 MULTIPLE-CONDUCTOR SHIELDED CABLES

****

NOTE: Ethylene propylene or cross-linked polyethylene insulated cables are considered higher quality, however cross-linked polyethylene insulation has been shown to tree (which breaks down the insulation at the microscopic level lowering the

insulation strength - see AEIC C8)when installed in wet environments. Use of ethylene propylene or anti-treeing cross-link is highly recommended.

When the required cables are not listed below, specify cables conforming to the following publications, and, when necessary, adding to or modifying the requirements of the referenced publications:

Rubber insulated - NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639, IEEE Std 532

Varnished cloth insulated - NEMA WC 27500

Thermoplastic insulated - IEEE Std 532

Cross-linked polyethylene insulated - NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639, AEIC C8, IEEE Std 532

Ethylene propylene rubber insulated - NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639, AEIC C8, IEEE Std 532

****

2.4.1 Varnished Cambric and Lead

****

NOTE: Specify multiple-conductor, varnished-cambric-insulated, lead-covered, shielded cable for 13,200/13,800-volt phase-to-phase circuits.

****

Provide multiple-conductor, varnished-cambric-insulated, lead-covered, shielded cable that conforms to NEMA WC 27500.

Provide cables that have a nonmetallic jacket over the lead sheath in accordance with paragraph entitled, "Nonmetallic Jacket," of this section.

2.4.2 Varnished Cambric with Interlocked Armor

****

NOTE: Specify multiple-conductor, varnished-cambric-insulated, interlocked-armor-covered, shielded cable for 13,200/13,800-volt phase-to-phase circuits.

****

Provide multiple-conductor, varnished-cambric-insulated, interlocked-armor-covered, shielded cable that conforms to NEMA WC 27500.

Apply close-fitting, interlocked-armor tape of [galvanized steel] [aluminum] over the jacket in accordance with NEMA WC 2.

2.4.3 [Natural] [Synthetic] Rubber with Interlocked Armor

****

NOTE: Specify multiple-conductor, natural- or

synthetic-rubber-insulated, interlocked-armor-covered, shielded cable for 6,900-volt and 13,200/13,800-volt phase-to-phase circuits.
****

Provide multiple-conductor, [natural] [synthetic]-rubber-insulated, interlocked-armor-covered, shielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639.

****
NOTE: Change interlocked-armor tape from galvanized steel to aluminum if necessary to suit the project requirements.
****

Apply close-fitting, interlocked-armor tape of galvanized steel over the jacket in accordance with NEMA WC 2.

2.4.4 Butyl Rubber with Neoprene Jacket

****
NOTE: Specify multiple-conductor, butyl-rubber-insulated, neoprene-jacketed, shielded cable for 6,900-volt phase-to-phase circuits and 13,200/13,800-volt phase-to-phase circuits.
****

Apply multiple-conductor, butyl-rubber-insulated, neoprene-jacketed, shielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639.

2.4.5 Cross-Linked Polyethylene with PVC Jacket

****
NOTE: Specify multiple-conductor, polyethylene-insulated, polyvinylchloride-jacketed, shielded cable for 6,900-volt phase-to-phase circuits and 13,200/13,800-volt phase-to-phase circuits.
****

Provide multiple-conductor, cross-linked polyethylene-insulated, polyvinylchloride-jacketed, shielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC C8. Provide taped shielding that consists of 0.13 millimeter 5-mil thick copper shielding lap applied over 0.30 millimeter 12-mil thick semiconducting tape. Wrap both helically with [10] [_____]-percent overlap, providing 100-percent coverage.

[Shield cross-linked polyethylene (XLP) single- and multiple-conductor cables for grounded and ungrounded neutral voltage ratings of 2,000 volts or more.

]2.4.6 Ethylene Propylene Rubber (EPR) with Jacketed Interlocked Armor

Provide multiple-conductor ethylene propylene rubber insulated interlocked armor covered shielded cables that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC C8.

[Shield ethylene propylene (EP) or ethylene propylene rubber (EPR), single- and multiple-conductor cables for grounded or ungrounded neutral voltage ratings of more that 8,000 volts.

]2.5 MULTIPLE-CONDUCTOR, NONSHIELDED CABLES

2.5.1 [Natural] [Synthetic] Rubber with Neoprene Jacket

****
NOTE: Specify multiple-conductor, natural- or synthetic-rubber-insulated, neoprene-jacketed, nonshielded cable for 2,400-volt phase-to-phase, ungrounded/grounded neutral circuits.
****

Provide multiple-conductor, [natural] [synthetic]-rubber-insulated, neoprene-jacketed, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659and NEMA WC 74/ICEA S-93-639.

2.5.2 Butyl Rubber with Neoprene Jacket

****
NOTE: Specify multiple-conductor, butyl-insulated, neoprene-jacketed, nonshielded cable for 2,400-volt phase-to-ground circuits (5,000-volt cable).
****

Provide multiple-conductor, [natural] [synthetic]-rubber-insulated, neoprene-jacketed, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659and NEMA WC 74/ICEA S-93-639.

2.5.3 Cross-Linked Polyethylene with PVC Jacket

****
NOTE: Specify multiple-conductor, polyethylene-insulated, polyvinylchloride-jacketed, nonshielded cable for 2,400-volt phase-to-ground circuits.
****

Provide multiple-conductor, polyethylene-insulated, polyvinylchloride-jacketed, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC C8.

2.5.4 Ethylene-Propylene with PVC Jacket

****
NOTE: Specify multiple-conductor, ethylene-propylene-insulated, polyvinylchloride-jacketed, nonshielded cable for 2,400-volt phase-to-ground circuits.
****

Provide multiple-conductor, ethylene-propylene-insulated, polyvinylchloride-jacketed, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC C8.

2.6 SINGLE-CONDUCTOR SHIELDED CABLES

2.6.1 Butyl Rubber with Neoprene Jacket

****
NOTE: Specify single-conductor, butyl-rubber-insulated, neoprene-jacketed, shielded cable for 6,900- and 13,200-volt phase-to-phase circuits.
****

Provide single-conductor, butyl-rubber-insulated, neoprene-jacketed, shielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639.

2.6.2 Cross-Linked Polyethylene with PVC Jacket

****
NOTE: Specify single-conductor, polyethylene-insulated, polyvinylchloride-jacketed, shielded cable for 6,900- and 13,200/13,800-volt phase-to-phase circuits.
****

Provide single-conductor, polyethylene-insulated, polyvinylchloride-jacketed, shielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC C8.

2.6.3 Cross-Linked Polyethylene with Interlocked Armor

****
NOTE: Specify single-conductor, polyethylene-insulated, polyvinylchloride-jacketed, shielded cable with interlocked armor for 6,900- and 13,200/13,800-volt phase-to-phase circuits.
****

Provide single-conductor, polyethylene-insulated, polyvinylchloride-jacketed, shielded cable with interlocked armor that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC C8.

Apply a close-fitting, interlocked-armor tape of [galvanized steel] [aluminum] over the jacket in accordance with NEMA WC 2.

2.6.4 Ethylene-Propylene-Rubber-Insulated with PVC Jacket

****
NOTE: Specify single-conductor, ethylene-propylene-rubber-insulated, polyvinylchloride-jacketed, shielded cable for 6,900- and 13,200/13,800 and 12,470-volt phase-to-phase circuits.
****

Provide single-conductor 15 KV cable assemblies that consist of: Class B stranded copper conductors, an extruded semiconducting shield over the conductors, 5.6 millimeter 220 mils of ethylene propylene rubber insulation, an extruded or other approved semiconducting shield, a 0.130

millimeter 5 mil minimum copper tape shield wrapped helically with a minimum [12.5] [_____] percent overlap and a PVC jacket.

Provide single-conductor, ethylene-propylene-insulated, polyvinylchloride-jacketed, shielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC C8.

2.7 SINGLE-CONDUCTOR NONSHIELDED CABLES

2.7.1 Butyl Rubber with Neoprene Jacket

****
NOTE: Specify single-conductor, butyl-rubber-insulated, neoprene-jacketed, nonshielded cable for 2,400-volt phase-to-ground circuits (5,000-volt cable only).
****

Provide single-conductor, butyl-rubber-insulated, neoprene-jacketed, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639.

2.7.2 Cross-Linked Polyethylene

****
NOTE: Specify single-conductor, cross-linked polyethylene-insulated, nonshielded cable for 2,400-volt phase-to-ground circuits (5,000-volt cable or less).
****

Provide single-conductor, cross-linked polyethylene-insulated, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC C8.

2.7.3 Ethylene-Propylene-Rubber-Insulated with PVC Jacket

****
NOTE: Specify single-conductor, ethylene-propylene-rubber-insulated, polyvinylchloride-jacketed, nonshielded cable for 2,400-volt phase-to-ground circuits (5,000-volt cable or less).
****

Provide single-conductor, ethylene-propylene-rubber-insulated, polyvinylchloride-jacketed, nonshielded cable that conforms to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, NEMA WC 74/ICEA S-93-639 and AEIC C8.

2.8 PORTABLE CABLES

****
NOTE: Specify multiple-conductor, butyl-rubber-insulated, neoprene-jacketed, shielded portable cable for 2,400-volt phase-to-phase circuits, 6,900-volt phase-to-phase ungrounded neutral circuits, and 13,200/13,800-volt phase-to-phase circuits.
****

Provide type SHD multiple-conductor, butyl-rubber-insulated, neoprene-jacketed, shielded portable cable conforming to NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639.

2.9 NONMETALLIC JACKET

2.9.1 Interlock Armored Cable

Provide nonmetallic, corrosion-resistant jacket over interlock-armored cable that is [[thermoplastic black] [colored] [polyvinylchloride]] [black polyethylene] conforming to [NEMA WC 27500] [NEMA WC 2] [NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639].

2.9.2 Lead-Sheathed Cable

Provide nonmetallic, corrosion-resistant jacket over lead-sheathed cable that is polyvinylchloride at least [2.8] [_____] millimeter [0.11] [_____] inch thick, conforming to NEMA WC 2. Provide cover that fits tightly to the lead sheath and is coated with a slipper compound.

2.9.3 Terminations

Provide potheads with grounding terminals and cast-[iron] [aluminum] bells that is rated as follows:

Indoor - 15 kilovolts (kV) rating, to withstand 45 kV ac for 10 seconds, minimum

Outdoor - 25 kV rating, to withstand 60 kV ac for 10 seconds, minimum

2.10 CABLE SUPPORTS AND FITTINGS

[Provide cable supports, related fittings, and accessories for use in corrosive underground locations, such as manholes and utility tunnels, with a factory applied coating of polyvinylchloride of at least [0.51] [_____] millimeter [20] [_____] mils thick. Provide polyvinylchloride (PVC) coated items that have a uniform thickness and be free of blisters, breaks, and holidays. Provide PVC compound that conforms to ASTM D 746.

][Provide cable racks, cable tray supports and related fittings that are UL listed [standard] [heavy]-duty nonmetallic [glass-reinforced nylon] [polycarbonate].

]# PART 3 EXECUTION

3.1 INSTALLATION

Install medium-voltage cables in accordance with NFPA 70.

Install cable in underground duct banks; in conduit above and below grade; inside buildings; by open wire method; on insulator hooks; on racks; in wall and ceiling mounted cable trays in utility tunnels and manholes; and by direct burial.

Secure cables with heavy duty cable ties in existing or new trays mounted horizontally, where cable rests on tray bottom. Install cable ties at minimum of [3000] [_____] millimeter [10] [_____] foot intervals.

Secure cables with [PVC coated] [metallic] [non-metallic] cable clamps, straps, hangers, or other approved supporting devices to tunnel walls, ceilings, and in new or existing cable trays mounted vertically, where tray bottom is in a vertical plane.

When field cuts or other damage occurs to the PVC coating, apply a liquid PVC patch to maintain the integrity of the coating. After the installation is complete, perform an inspection to ensure the absence of voids, pinholes, or cuts.

Ensure that all cable tray is properly secured and supported prior to installing new armored cable. Add new permanent and/or temporary tray support devices as required to preclude cable tray failure during cable pulling or after cable is installed.

Cable or conductors of a primary distribution system will be rejected when installed openly in cable trays or openly racked along interior walls; in the same raceway or conduit with ac/dc control circuits or ac power circuits operating at less than 600 volts; or in a manner allowing cable to support its own weight.

3.1.1 Moisture-Testing Before Pulling

Moisture-test cable that has paper insulation before before pulling it into underground ducts. Ensure that radii of bends, potheads, fittings, cable risers, and other conditions are suitable for the cable and conform with the recommendations of the cable manufacturer.

3.1.2 Protection During Splicing Operations

Provide blower to force fresh air into manholes or confined areas where free movement or circulation of air is obstructed. Make waterproof protective coverings available on the work site to provide protection against moisture while a splice is being made. Use pumps to keep manholes dry during splicing operations. Never make a splice or termination with the interior of a cable exposed to moisture. Moisture-test conductor insulation paper before the splice is made. Use a manhole ring at least [150] [_____] millimeter [6] [_____]-inches above ground around the manhole entrance to keep surface water from entering the manhole. Plug unused ducts and stop water seepage through ducts in use before the splice is started.

3.1.3 Duct Cleaning

****
NOTE: Delete the heading and the following paragraph if the installation of power cables is in ducts and manholes provided under this project. Provisions for duct cleaning are adequately covered in Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION.
****

Thoroughly clean ducts before installation of power cables. Pull a standard flexible mandrel through each duct to loosen particles of earth, sand, or foreign material in the line. Provide not less than [300] [_____] millimeter [12] [_____]-inches long mandrel with a diameter 13 millimeter 1/2 inch less than the inside diameter of the duct. Then pull a brush with stiff bristles through each duct to remove the loosened particles. Provide

brush diameter that is the same as or slightly larger than the diameter of the duct.

3.1.4 Pulling Cables in Ducts, Manholes and Utility Tunnels

Pull medium-voltage cables into ducts and utility tunnels with equipment designed for this purpose, including power-driven winch, cable-feeding flexible tube guide, cable grips, and lubricants. Employ a sufficient number of trained personnel and equipment to ensure the careful and proper installation of the cable.

Set up cable reel at the side of the manhole or tunnel hatch opening and above the duct or hatch level, allowing the cable to enter through the opening without reverse bending. Install flexible tube guide through the opening in a manner that prevents the cable from rubbing on the edges of any structural member.

Allow for a pulling force for a cable grip on lead-sheathed cable that does not exceed [6700] [_____] newton per 650 square millimeter [1,500] [_____] pounds per square inch of sheath cross-sectional area. Use a dynamometer in the pulling line to ensure that the pulling force is not exceeded. Allow for a pulling force for a nonmetallic-sheathed cable that does not exceed the smaller of 4400 newton 1,000 pounds or a value computed from the following equation:

TM = 0.008 X N X CM

Where: TM = maximum allowable pulling tension in newton pounds

N = number of conductors in the cable

CM = cross-sectional area of each conductor in square millimeter circular mils

Unreel cable from the top of the reel. Carefully control payout. Make cable to be pulled be attached through a swivel to the main pulling wire by means of a [pulling eye] [suitable cable grip permitted only on cables less than 60 meter 200-feet long and less than 50 millimeter 2 inches in diameter].

Use woven-wire cable grips to grip the cable end when pulling small cables and short straight lengths of heavier cables.

Attach pulling eyes to the cable conductors to prevent damage to the cable structure.

Use pulling eyes and cable grips together for nonmetallic sheathed cables to prevent damage to the cable structure.

Provide a minimum bending radius in accordance with the following:

CABLE TYPE	MINIMUM BENDING RADIUS MULTIPLIER TIMES CABLE DIAMETER
RUBBER- AND PLASTIC-INSULATED CABLE WITH OR WITHOUT INTERLOCKED ARMOR	
[Nonshielded cables	8]

CABLE TYPE	MINIMUM BENDING RADIUS MULTIPLIER TIMES CABLE DIAMETER
[Shielded cables with shielding tape	12]
[Shielded cables with shielding wire	8]
PAPER-INSULATED AND LEAD-COVERED CABLES, SHIELDED OR NONSHIELDED	
[Cables without armor	10]
[Cables with wire armor	12]
VARNISHED-CAMBRIC-INSULATED CABLES WITH OR WITHOUT LEAD SHEATH, SHIELDED OR NONSHIELDED	
[Cables without armor	8]
[Cables with wire armor	12]

Liberally coat cables with a suitable cable-pulling lubricant as it enters the tube guide or duct. Use grease and oil lubricants only on lead-sheathed cables. Cover nonmetallic sheathed cables with wire-pulling compounds when required which have no deleterious effects on the cable. Provide rollers, sheaves, or tube guides around which the cable is pulled that conform to the minimum bending radius of the cable.

Pull cables into ducts at a speed not to exceed [_____] meter per second [50] [_____] feet per minute and not in excess of maximum permissible pulling tension specified by the cable manufacturer. Cable pulling using a vehicle is not permitted. Stop pulling operations immediately with any indication of binding or obstruction and do not resume until such difficulty is corrected. Provide sufficient slack for free movement of cable due to expansion or contraction.

Make cable splices made up in manholes or utility tunnels that are firmly supported on cable racks as indicated. Do not pull cable splices in ducts. Overlap cable ends at the ends of a section to provide sufficient undamaged cable for splicing. Make cables to be spliced in manholes or utility tunnels overlap the centerline of the proposed joint by not less than [600] [_____] millimeter [2] [_____] feet.

Provide cables cut in the field that have the cut ends immediately sealed to prevent entrance of moisture. Seal nonleaded cables with rubber tape wrapped down to [75] [_____] millimeter [3] [_____] inches from the cable end. Cover-wrap rubber tape with polyvinylchloride tape. Seal lead-covered cables with wiping metal making a firm bond with the end of the sheath or with a disk of lead fitted over the end and wiped to the sheath.

3.1.5 Splices and Terminations

Make splices in manholes or tunnels except where cable terminations are

specifically indicated. Expedite splicing and terminating of cables to minimize exposure and cable deterioration.

Terminate cables in potheads. Dry terminations with medium voltage pennants, preformed, and hand wrapped stress cones are allowed for terminating cables. Provide potheads with adequate means for making external connections to the cable conductors of [single-] [multiple-] conductor cables; protecting the cable insulation against moisture, oil, or other contaminant; physically protecting and supporting cables, and maintaining the insulation level of the cable.

Field-fabricate Pothead terminations from termination kits supplied by and in accordance with the pothead manufacturer's recommendations for the type, size, and electrical characteristics of the cable.

Installation includes built-up or prefabricated heat or cold shrink stress-relief cones at the terminals of all shielded cables and at the terminals of single-conductor lead-covered cables rated 15 kV and above, ungrounded.

Field fabricate cable splices from splicing kits supplied by and in accordance with the cable manufacturer's recommendations for the type, size, and electrical characteristics of the cable specified. Locate cable splices in manholes midway between cable racks on walls of manholes and supported with cable arms at approximately the same elevation as the enclosing duct.

Cable splices in the tunnel which are not installed in cable trays, install on cable racks or by other approved methods which minimize physical stress on the splice connections. Support splices at approximately the same elevation as the installed cable except where space limitations or existing cable length limitations make this method impractical or impossible.

Support all universal demountable splices in such manner so as to minimize physical stress on the splice connections. Support each cable end termination using a pair of saddle type supports under the cable end termination and/or cable with a minimum [300] [_____] millimeter [12] [_____] inches and a maximum [750] [_____] millimeter [30] [_____] inches separation between the supports. Secure cable end termination and cable to the supports in such a manner as to prevent movement of termination or cable at the support. Install saddle type supports on galvanized steel framing channel anchored to the wall or securely fastened to the cable tray or installed by other approved methods.

3.1.6 Multiple-Conductor Potheads

Provide multiple-conductor potheads that are hermetically sealed capnut type and that are suitable for the type, size, and electrical characteristics of the cable. Provide potheads that consist of bells or bodies with bell [caps] [lids], bushing, cable connectors, lugs, and entrance fittings.

Provide pothead bells or bodies that are cast [iron] [aluminum] with mounting brackets as required, pipe plugs for fillings and vent holes, machine-flanged surfaces for [bell caps] [lids], and cable entrance fittings. Provide pothead [bell caps] [lids] for cables up to [130 square millimeter] [250 kc mils] [250 amperes] that are cast [iron] [aluminum]; and for cables of larger size and higher current ratings that are cast [aluminum] [bronze] [nonmagnetic metal casting]. Provide [bell caps]

[lids] that have matching machined flanged surfaces for sealing with gasket and cap-screw connections.

Provide bushings that are glazed wet-process electrical porcelain insulators, factory assembled and hermetically sealed to bell [cap] [lid].

Provide cable connectors that are high-conductivity copper accurately machined and threaded for internal and external electrical connections. Provide cross-sectional and contact areas that are adequate to carry the full-load current rating of the conductors. Provide solder type cable connectors with gasket seal between the connector and bushing.

Provide cable-entrance fittings that are cast-bronze wiping-sleeve type for lead-covered cable, and cast-aluminum positive-sealed stuffing boxes for nonlead-covered cables. Provide cast iron conduit couplings and armor base fittings.

Three-conductor potheads with a neutral stud and lug are allowed in lieu of four-conductor potheads in four-wire grounded neutral systems.

Provide completely filled potheads, leaving no gaps or voids, with an insulating compound suitable for the type of cable, insulation, voltage rating, and ambient operating temperatures in accordance with the pothead manufacturer's recommendations. Ground pothead parts that do not carry current.

3.1.7 Single-Conductor Potheads

Provide single-conductor potheads that are the hermetically sealed capnut type and that are suitable for the type, size, and electrical characteristics of the cable specified. Provide potheads that consist of cast bodies, bushings, cable connectors, lugs, and entrance fittings.

Provide pothead bodies that are metal castings with mounting brackets, when required, pipe plugs for filling and vent holes, and machined flanged surface for cable-entrance fitting. Provide bodies that are cast iron for cables up to [130 square millimeter] [250 kc mils] [250 amperes], and cast [aluminum] [bronze] [nonmagnetic metal casting] for cable of larger size and higher current ratings.

Provide bushings that are glazed wet-process electrical porcelain insulators, factory assembled and hermetically sealed to the pothead body.

Provide cable connectors that are high-conductivity copper accurately machined and threaded for internal and external electrical connections. Provide adequate cross-sectional and contact areas to carry the full-load current rating of the conductors. Provide solder type cable connectors with gasket seal between the connector and bushing.

Completely fill potheads, leaving no gaps or voids, with an insulating compound suitable for the type of cable, insulation, voltage rating, and ambient operating temperatures in accordance with the pothead manufacturer's recommendations. Ground pothead parts that do not carry current.

3.2 FIELD TESTING

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NOTE: If the specified system is identified as

critical, configured, or mission essential, use Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS to establish predictive and acceptance testing criteria, above and beyond that listed below.

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Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

Subject each to dielectric-absorption tests and high-voltage tests after the installation of high-voltage power cables has been completed, including splices, joints, and terminations, and before the cable is energized.

Provide test equipment, labor, and technical personnel as necessary to perform the electrical acceptance tests.

Make arrangements to have tests witnessed and approved by the Contracting Officer.

Completely isolate each power-cable installation from extraneous electrical connections at cable terminations and joints. Observe safety precautions.

First give each power cable a full dielectric-absorption test with 5000-volt insulation-resistance test set. Apply test for a long enough time to fully charge the cable. Record readings every 15 seconds during the first 3 minutes of test and at 1 minute intervals thereafter. Continue test until three equal readings, 1 minute apart, are obtained. Minimum reading is 200 megohms at an ambient temperature of 20 degrees C 68 degrees F. Correct readings taken at other than 20 degrees C 68 degrees F ambient temperatures.

Upon successful completion of the dielectric absorption tests, subject the cable to a direct-current high-potential test for 5 minutes with test voltages applied in accordance with AEIC CS1 and IEEE 400.2 for paper-impregnated, lead-covered cable; AEIC C8 and IEEE 400.2 for cross-linked, polyethylene-insulated cable; and AEIC C8 and IEEE 400.2 for ethylene propylene rubber-insulated cable.

Record leakage current readings every 30 seconds during the first 2 minutes and every minute thereafter for the remainder of the test. When the leakage current continues to increase after the first minute, immediately terminate the test and take steps to find and correct the fault. When a second test becomes necessary, repeat this test procedure.

Upon satisfactory completion of the high-potential test, give the cable a second dielectric-absorption test as before.

Provide results of the second dielectric-absorption test that agree with the first test and that indicate no evidence of permanent injury to the cable caused by the high-potential test.

Record test data and include identification of cable and location, megohm readings versus time, leakage current readings versus time, and cable temperature versus time.

Final acceptance depends upon the satisfactory performance of the cable under test. Do not energize cable until recorded test data has been approved by the Contracting Officer Provide final test reports to the

Contracting Officer. Provide reports with a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Report - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

Perform Radiographic tests on all potheads at the discretion of the Contracting Officer to determine if voids exist in the pothead. Rework unacceptable terminations at no additional expense to the Government.

-- End of Section --