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USACE / NAVFAC / AFCEC / NASA UFGS-26 05 13.00 40 (November 2016)  
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Preparing Activity: NASA Superseding  
UFGS-26 05 13.00 40 (November 2013)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2017

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#### SECTION 26 05 13.00 40

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SECTION 26 05 13.00 40

MEDIUM-VOLTAGE CABLES  
11/16

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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 the 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 item(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).

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### PART 1 GENERAL

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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.

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

## 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 Reference Identifier (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	(2012) Impregnated-Paper-Insulated, Metallic Sheathed Cable, Solid Type

### ASTM INTERNATIONAL (ASTM)

ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM D746	(2014) Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact

### INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 383	(2015) Qualifying Class 1E Electric Cables and, Field Splices for Nuclear Power Generating Stations 2004
IEEE 400.2	(2013) 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 (2014) Standard for Nonshielded Cables  
Rated 2001-5000 Volts for use in the  
Distribution of Electric Energy

NEMA WC 27500 (2015) 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 (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; ERTA 1-2 2017; TIA 17-1; TIA 17-2)  
National Electrical Code

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-228 (Rev A) Testing Methods for Cable and  
Wire, Insulated

1.2 DEFINITIONS

Medium-voltage power cables include all cables rated above 600 volts up to  
35,000 volts.

1.3 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.

The Guide Specification technical editors have  
designated those items that require Government  
approval, due to their complexity or criticality,  
with a "G." Generally, other submittal items can be  
reviewed by the Contractor's Quality Control  
System. Only add a "G" to an item, 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.

Use the "S" Classification only in SD-11 Closeout Submittals. An "S" following a submittal item indicates that the submittal is required for the Sustainability eNotebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

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

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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.] Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

#### SD-03 Product Data

Multiple-Conductor Shielded Cables; G[, [\_\_\_\_]]

Multiple-Conductor Nonshielded Cables; G[, [\_\_\_\_]]

Single-Conductor Shielded Cables; G[, [\_\_\_\_]]

Single-Conductor Nonshielded Cables; G[, [\_\_\_\_]]

Portable Cables; G[, [\_\_\_\_]]

Nonmetallic Jacket; G[, [\_\_\_\_]]

#### SD-06 Test Reports

Dielectric-Absorption Tests

Medium-Voltage Tests

Radiographic Tests; G[, [\_\_\_\_]]

#### SD-07 Certificates

Lead Sheath

Flammability

Minimum Bending Radius

Medium-Voltage Tests

Dielectric Absorption Tests

Cable Splicers

SD-08 Manufacturer's Instructions

Medium-Voltage Power Cables

Pothead Terminations

#### 1.4 QUALITY CONTROL

Provide a list of installed products to the Contracting Officer before performing the specified work. Show the qualifications of the cable splicers .

Ensure that cable splicers performing splicing have [5] [\_\_\_\_\_] years of experience in cable splicing and terminations. Ensure that 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.

##### 1.4.1 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 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 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 that building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system and its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work.

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

#### 1.5 DELIVERY, STORAGE, AND HANDLING

Ship cables on reels in a way that protects the cable from mechanical injury. Hermetically seal and attach each end of each length of cable to the reel.

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

## PART 2 PRODUCTS

### 2.1 SYSTEM DESCRIPTION

#### 2.1.1 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:

[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.

### 2.2 EQUIPMENT

Ensure that ethylene-propylene rubber and cross-linked polyethylene-insulated conductors are lead-free.

#### 2.2.1 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

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#### 2.2.1.1 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 NONMETALLIC JACKET.

#### 2.2.1.2 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.

#### 2.2.1.3 [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.

#### 2.2.1.4 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.

#### 2.2.1.5 Cross-Linked Polyethylene with PVC Jacket

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**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.

#### ]2.2.1.6 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 than 8,000 volts.

#### ]2.2.2 Multiple-Conductor, Nonshielded Cables

##### 2.2.2.1 [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-96-659 and NEMA WC 74/ICEA S-93-639.

##### 2.2.2.2 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-96-659 and NEMA WC 74/ICEA S-93-639.

#### 2.2.2.3 Cross-Linked Polyethylene with PVC Jacket

\*\*\*\*\*

**NOTE: Specify multiple-conductor, polyethylene-insulated, PVC-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.

#### 2.2.2.4 Ethylene-Propylene with PVC Jacket

\*\*\*\*\*

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

\*\*\*\*\*

Provide multiple-conductor, ethylene-propylene-insulated, PVC-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.

### 2.2.3 Single-Conductor Shielded Cables

#### 2.2.3.1 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.

#### 2.2.3.2 Cross-Linked Polyethylene with PVC Jacket

\*\*\*\*\*

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

\*\*\*\*\*

Provide single-conductor, polyethylene-insulated, PVC-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.

### 2.2.3.3 Cross-Linked Polyethylene with Interlocked Armor

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

Provide single-conductor, polyethylene-insulated, PVC-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.

### 2.2.3.4 Ethylene-Propylene-Rubber-Insulated with PVC Jacket

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

Provide single-conductor 15 kV rated cable assemblies that consist of the following: 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, PVC-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.

### 2.2.4 Single-Conductor Nonshielded Cables

#### 2.2.4.1 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.

#### 2.2.4.2 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.

#### 2.2.4.3 Ethylene-Propylene-Rubber-Insulated with PVC Jacket

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

Provide single-conductor, ethylene-propylene-rubber-insulated, PVC-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.

#### 2.2.5 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 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.

#### 2.2.6 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 PVC of at least [0.51] [\_\_\_\_\_] millimeter [20] [\_\_\_\_\_] mils thick. Provide PVC coated items that have a uniform thickness and are free of blisters, breaks, and holidays. Provide PVC compound that conforms to ASTM D746.

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

### ]2.3 COMPONENTS

#### 2.3.1 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.

## 2.3.2 Nonmetallic Jacket

### 2.3.2.1 Interlock Armored Cable

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

### 2.3.2.2 Lead-Sheathed Cable

Provide a nonmetallic, corrosion-resistant jacket over lead-sheathed cable that is PVC at least [2.8] [\_\_\_\_\_] millimeter [0.11] [\_\_\_\_\_] inch thick. Provide cover that fits tightly against the lead sheath and is coated with a slipper compound.

### 2.3.2.3 Terminations

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

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

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

## 2.4 MATERIALS

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NOTE: If aluminum is to be specified for any of the wire purchased, revise the paragraphs accordingly.

Conductors for wire and cable may be aluminum or copper. Aluminum conductors may be considered for use in accordance with NFPA 70, Article 310.106. When used, aluminum conductor material must be AA-8000 series electrical grade aluminum alloy. The designer must consider several factors when deciding to use aluminum instead of copper including comparisons of electrical properties, mechanical properties, environmental properties specific to the intended installation, reliability, and cost. Specifications for wire and cable may be written to permit either aluminum or copper conductors where aluminum is suitable for the application, suitably reliable, and is determined to be more economical than copper.

Aluminum conductors should be permitted only where cost comparisons show an overall savings and after a careful evaluation of the corrosion problems associated with their use. They should only be allowed where installers are qualified to make reliable connections with them. Proper wire and cable connectors must be suitably rated for installation with the conductor material to which they are applied. Wire and cable connectors used with aluminum conductors must be suitably rated, termination must be prepared correctly, and an antioxidant must be applied when the connector is

installed. Costs should be compared to between all pertinent items such as installation, conduit, tray, tunnel and duct banks, lifetime costs of energy losses if significant, and differences in ventilation needs if losses are evaluated. Conductors should have the required current-carrying capacities, the required short circuit capacities, and should be satisfactory with respect to voltage drop. Aluminum conductors should be sized to have equal or less resistance than the alternate copper conductors unless the total cost comparison, including losses, shows a net advantage otherwise. In such cases where the engineering costs to properly compare the use of the two materials will exceed any possible savings to be achieved by aluminum, the arbitrary choice of copper may be the best policy.

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#### 2.4.1 Conductors

Ensure that conductors conform to the applicable requirements of NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639. Ensure that conductors are solid copper conforming to ASTM B3 and that they are bare, or tin- or lead-alloy-coated, according to the type of insulation used. [Ensure that aluminum conductors are Type AA-8000 aluminum conductors. Do not use Type 1350 aluminum conductors. Do not intermix copper and aluminum conductors in the same raceway.]"

#### 2.5 TESTS, INSPECTIONS, AND VERIFICATIONS

Provide certificates showing that the cable manufacturer has made the following factory-conducted tests on each shipping length of cable. Before cable is delivered, provide certified copies of test data that shows conformance with the referenced standards and is approved.

##### [a. Flammability

For cables not to be enclosed in metallic conduit, test 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].

##### ] [b. Minimum Bending Radius

#### ]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 the cable rests on the tray bottom. Install cable ties at a 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 the 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 that the coating has no voids, pinholes, or cuts.

Before installing new armored cable, ensure that cable trays are properly secured and supported. Add new permanent 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 by the Contracting Officer when installed openly in cable trays or openly racked along interior walls; in the same raceway or conduit with ac or 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 pulling the cable into underground ducts. Ensure that radii of bends, potheads, fittings, cable risers, and other conditions are suitable for the cable and conform to the recommendations of the cable manufacturer.

#### 3.1.2 Protection During Splicing Operations

Provide a blower to force fresh air into manholes or confined areas where free movement or circulation of air is obstructed. Have waterproof protective coverings available on the work site to protect 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 the 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. Before starting the splice, plug unused ducts and stop water seepage through ducts in use.

#### 3.1.3 Duct Cleaning

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**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 UNDERGROUND ELECTRICAL DISTRIBUTION.**  
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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. Use a mandrel that is not less than [300] [\_\_\_\_\_] millimeter [12] [\_\_\_\_\_] inches long 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. Use a brush with a 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 a power-driven winch, cable-feeding flexible tube guide, cable grips, and lubricants. Employ a sufficient number of trained personnel and equipment to ensure correct installation of the cable.

Set up the 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 a flexible tube guide through the opening in a manner that prevents the cable from rubbing against the edges of structural members.

Ensure that the pulling force for a cable grip on lead-sheathed cable 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. Ensure that the pulling force for a nonmetallic-sheathed cable does not exceed the smaller of 4400 newton 1,000 pounds or a value computed from the following equation:

$$TM = 0.008 \times N \times CM$$

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. Attach cable to be pulled 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].

When pulling small cables and short straight lengths of heavier cables, use woven-wire cable grips to grip the cable end.

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

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

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]
[Shielded cables with shielding wire]	[12]

CABLE TYPE	MINIMUM BENDING RADIUS MULTIPLIER TIMES CABLE DIAMETER
[Shielded cables with shielding tape]	[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 the cable enters the tube guide or duct. Use grease and oil lubricants only on lead-sheathed cables. Cover nonmetallic sheathed cables with wire-pulling compounds that 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. Ensure that cable pulling is done without using a vehicle. Stop pulling operations immediately if binding or obstruction is indicated and do not resume pulling operations until such difficulty is corrected. Provide sufficient slack for the cable to move freely when the cable expands or contracts.

Use cable racks to support cables when making cable splices in manholes or utility tunnels. 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.

Immediately seal cables cut in the field to keep out moisture. Seal nonleaded cables with rubber tape wrapped down to [75] [\_\_\_\_\_] millimeter [3] [\_\_\_\_\_] inches from the cable end. Cover-wrap rubber tape with PVC 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 in order to minimize exposure and cable deterioration.

Terminate cables in potheads. Use dry terminations with medium-voltage pennants, preformed, and hand-wrapped stress cones for terminating cables. Install potheads with a 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 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.

Ensure that 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 the cable racks on the walls of the manholes and supported with cable arms at approximately the same elevation as the enclosing duct.

If cable splices in the tunnel are not installed in cable trays, install the cable splices on cable racks or by other approved methods that 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 a manner that minimizes physical stress on the splice connections. Support each cable end termination using a pair of saddle supports under the cable end termination or cable with a minimum [300] [\_\_\_\_\_] millimeter [12] [\_\_\_\_\_] inches and a maximum [750] [\_\_\_\_\_] millimeter [30] [\_\_\_\_\_] inches separation between the supports. Secure the cable end termination and cable to the supports in a manner that prevents movement of termination or cable at the support. Install saddle supports on a galvanized steel framing channel that is anchored to the wall, securely fastened to the cable tray, or installed by other approved methods.

#### 3.1.6 Multiple-Conductor Potheads

Install multiple-conductor capnut potheads that are hermetically sealed, and suitable for the type, size, and electrical characteristics of the cable. Install potheads consisting 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, machined-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.

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

Provide cable connectors that are high-conductivity copper, accurately machined, and threaded for internal and external electrical connections.

Ensure that cross-sectional and contact areas are adequate to carry the full-load current rating of the conductors. Provide solder cable connectors with a gasket seal between the connector and bushing.

Provide cast-bronze wiping-sleeve cable-entrance fittings 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.

Use 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

Use single-conductor potheads with a hermetically sealed capnut. Ensure that potheads 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 a machined-flanged surface for cable-entrance fittings. Use cast-iron bodies for cables up to [130 square millimeter] [250 kc mils] [250 amperes], and cast [aluminum] [bronze] [nonmagnetic metal casting] for cables of larger size and higher current ratings.

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

Install high-conductivity copper cable connectors accurately machined and threaded for internal and external electrical connections. Ensure 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 QUALITY CONTROL

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

Provide test equipment, labor, and technical personnel 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 a 5000-volt insulation-resistance test set. Apply the test for enough time to fully charge the cable. Record readings every 15 seconds during the first 3 minutes of the test and at 1-minute intervals thereafter. Continue the test until three equal readings, 1 minute apart, are obtained. Ensure that the minimum reading is 200 megohms at an ambient temperature of 20 degrees C 68 degrees F. Correct the readings that were not taken at 68 degrees F ambient temperature.

Upon successful completion of the dielectric absorption tests, subject the cable to a direct-current high-potential test for 5 minutes applying test voltages 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 that the cable has been permanently injured by the high-potential test.

Record test data identifying the 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 of the dielectric absorption tests and medium-voltage tests 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.

### 3.3 CLOSEOUT ACTIVITIES

Provide manufacturer's instructions showing the recommended sequence and method of installation for medium-voltage power cables and pothead terminations.

-- End of Section --