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USACE / NAVFAC / AFCESA / NASA **NASA-16124S (December 2005)**

Preparing Activity: NASA **MasterFormat™ 2004 - 26 05 13.00 40**
Superseding
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UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 16124S

MEDIUM VOLTAGE CABLE

12/05

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SECTION 16124S

MEDIUM VOLTAGE CABLE
12/05

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NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.

This section covers 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.

Drawings should show plan layout of power cable and power-cable terminations. Electrical riser diagrams should show size, type, electrical characteristics, and raceway system of power cables and type of cable termination.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.
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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 will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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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 CS1	(1990; 11th Ed) Impregnated-Paper-Insulated, Metallic Sheathed Cable, Solid Type
AEIC CS5	(1994; 10th Ed) Specifications for Cross-Linked Polyethylene Insulated Shielded Power Cables Rated 5 Through 46KV
AEIC CS6	(1996; 6th Ed) Specifications for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 Through 69KV

ASTM INTERNATIONAL (ASTM)

ASTM B 3	(2001) Standard Specification for Soft or Annealed Copper Wire
ASTM D 746	(1998e1) Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE Std 383	(1974; R 1992) Standard for Type Test Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations
IEEE Std 400	(2001) Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA WC 2	(1980; R 1985) Steel Armor and Associated Coverings for Impregnated-Paper-Insulated Cables (ICEA S-67-401)
NEMA WC 3	(1992) Rubber-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-19-81)
NEMA WC 4	(1988) Varnished-Cloth-Insulated Wire and

	Cable for the Transmission and Distribution of Electrical Energy (ICEA S-65-375)
NEMA WC 7	(1988) Cross-linked Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-66-524)
NEMA WC 8	(1993) Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-68-516)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code 2005 Edition

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

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

1.2 DEFINITIONS

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

1.3 GENERAL REQUIREMENTS

****

NOTE: If Section 16003S GENERAL ELECTRICAL PROVISIONS is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.

****

Section 16003S GENERAL ELECTRICAL PROVISIONS applies to work specified in this section.

Certificates shall be provided for the following showing that the cable manufacturer has made factory-conducted tests on each shipping length of cable. Certified copies of test data shall show conformance with the referenced standards and shall be approved prior to delivery of cable.

1.4 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept 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, a code of up to three characters within the submittal tags may be used 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 will review the submittal for the Government.] Submit the following in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment and performance data and manufacturer's catalog data shall be provided 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

Test reports for the following shall be in accordance with the paragraph entitled, "Field Testing," of this section.

Dielectric Absorption Tests
High-Voltage Tests
Radiographic Tests

SD-07 Certificates

Listing of products installed shall be provided showing qualifications of Cable Splicers to the Contracting Officer prior to specified work.

Certificates shall be provided for the following:

Lead Sheath
Flammability
Minimum Bending Radius
High-Voltage Tests
Dielectric Absorption Tests
Cable Splicers

SD-08 Manufacturer's Instructions

Manufacturer's instructions shall be provided showing the recommended sequence and method of installation for the following:

Medium-Voltage Power Cables
High-Voltage Power Cables
Pothead Terminations

1.5 QUALIFICATIONS

Cable splicers performing splicing shall have [5] [_____] years experience in cable splicing and terminations. Once a termination or splice has been started by a worker, the same person shall complete that particular splice. Each termination and splice shall be started and completed in one continuous work period.

1.6 CABLE VOLTAGE RATINGS

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

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

1.7 SHIPMENT

Cable shall be shipped on reels such that the cable will be protected from mechanical injury. Each end of each length of cable shall be hermetically sealed and securely attached to the reel.

Minimum reel drum diameter shall be [14] [_____] times the overall diameter of the cable. A pulling eye shall be installed by the manufacturer for each length of cable supplied for installation in ducts, manholes, and utility tunnels.

PART 2 PRODUCTS

2.1 CONDUCTORS

Conductors shall be solid copper conforming to ASTM B 3.

2.2 CABLE IDENTIFICATION

Cables shall 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. Information shall be closely grouped on the tape at 300 millimeter 1-foot

intervals to permit complete identification.

2.3 FLAMMABILITY

Cables not to be enclosed in metallic conduit shall be tested for flammability in accordance with [FED-STD 228, Method 5221 [vertical], [spark]] [IEEE Std 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 CS5)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, the designer should specify cables conforming to the following publications, and, when necessary, adding to or modifying the requirements of the referenced publications:

Rubber insulated - NEMA WC 3, IEEE Std 532

Varnished cloth insulated - NEMA WC 4

Thermoplastic insulated - IEEE Std 532

Cross-linked polyethylene insulated - NEMA WC 7, AEIC CS5, IEEE Std 532

Ethylene propylene rubber insulated - NEMA WC 8, AEIC CS6, IEEE Std 532

****

2.4.1 Varnished Cambric and Lead

****

NOTE: Multiple-conductor, varnished-cambric-insulated, lead-covered, shielded cable should be specified for 13,200/13,800-volt phase-to-phase circuits.

****

Multiple-conductor, varnished-cambric-insulated, lead-covered, shielded cable shall conform to NEMA WC 4.

Cables shall have a nonmetallic jacket over the lead sheath in accordance with paragraph entitled, "Nonmetallic jacket."

2.4.2 Varnished Cambric with Interlocked Armor

****

NOTE: Multiple-conductor,

varnished-cambric-insulated, interlocked-armor-covered, shielded cable should be specified for 13,200/13,800-volt phase-to-phase circuits.

****

Multiple-conductor, varnished-cambric-insulated, interlocked-armor-covered, shielded cable shall conform to NEMA WC 4.

Close-fitting, interlocked-armor tape of [galvanized steel] [aluminum] shall be applied over the jacket in accordance with NEMA WC 2.

2.4.3 [Natural] [Synthetic] Rubber with Interlocked Armor

****

NOTE: Multiple-conductor, natural- or synthetic-rubber-insulated, interlocked-armor-covered, shielded cable should be specified for 6,900-volt and 13,200/13,800-volt phase-to-phase circuits.

****

Multiple-conductor, [natural] [synthetic]-rubber-insulated, interlocked-armor-covered, shielded cable shall conform to NEMA WC 3.

****

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

****

Close fitting, interlocked-armor tape of galvanized steel shall be applied over the jacket in accordance with NEMA WC 2.

2.4.4 Butyl Rubber with Neoprene Jacket

****

NOTE: Multiple-conductor, butyl-rubber-insulated, neoprene-jacketed, shielded cable should be specified for 6,900-volt phase-to-phase circuits and 13,200/13,800-volt phase-to-phase circuits.

****

Multiple-conductor, butyl-rubber-insulated, neoprene-jacketed, shielded cable shall conform to NEMA WC 3.

2.4.5 Cross-Linked Polyethylene with PVC Jacket

****

NOTE: Multiple-conductor, polyethylene-insulated, polyvinylchloride-jacketed, shielded cable should be specified for 6,900-volt phase-to-phase circuits and 13,200/13,800-volt phase-to-phase circuits.

****

Multiple-conductor, cross-linked polyethylene-insulated, polyvinylchloride-jacketed, shielded cable shall conform to NEMA WC 7 and AEIC CS5. Taped shielding shall consist of 0.13 millimeter 5-mil thick copper shielding lap applied over 0.30 millimeter 12-mil thick

semiconducting tape. Both shall be wrapped helically with [10] [_____]-percent overlap, providing 100-percent coverage.

[Cross-linked polyethylene (XLP) single- and multiple-conductor cables shall be shielded for grounded and ungrounded neutral voltage ratings of 2,000 volts or more.]

2.4.6 Ethylene Propylene Rubber (EPR) with Jacketed Interlocked Armor

Multiple-conductor ethylene propylene rubber insulated interlocked armor covered shielded cables shall conform to NEMA WC 8 and AEIC CS6.

[Ethylene propylene (EP) or ethylene propylene rubber (EPR), single- and multiple-conductor cables shall be shielded 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: Multiple-conductor, natural- or synthetic-rubber-insulated, neoprene-jacketed, nonshielded cable should be specified for 2,400-volt phase-to-phase, ungrounded/grounded neutral circuits.
****

Multiple-conductor, [natural] [synthetic]-rubber-insulated, neoprene-jacketed, nonshielded cable shall conform to NEMA WC 3.

2.5.2 Butyl Rubber with Neoprene Jacket

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

Multiple-conductor, [natural] [synthetic]-rubber-insulated, neoprene-jacketed, nonshielded cable shall conform to NEMA WC 3.

2.5.3 Cross-Linked Polyethylene with PVC Jacket

****
NOTE: Multiple-conductor, polyethylene-insulated, polyvinylchloride-jacketed, nonshielded cable should be specified for 2,400-volt phase-to-ground circuits.
****

Multiple-conductor, polyethylene-insulated, polyvinylchloride-jacketed, nonshielded cable shall conform to NEMA WC 7 and AEIC CS5.

2.5.4 Ethylene-Propylene with PVC Jacket

****
NOTE: Multiple-conductor, ethylene-propylene-insulated, polyvinylchloride-jacketed, nonshielded cable should

be specified for 2,400-volt phase-to-ground circuits.
****

Multiple-conductor, ethylene-propylene-insulated, polyvinylchloride-jacketed, nonshielded cable shall conform to NEMA WC 8 and AEIC CS6.

2.6 SINGLE-CONDUCTOR SHIELDED CABLES

2.6.1 Butyl Rubber with Neoprene Jacket

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

Single-conductor, butyl-rubber-insulated, neoprene-jacketed, shielded cable shall conform to NEMA WC 3.

2.6.2 Cross-Linked Polyethylene with PVC Jacket

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

Single-conductor, polyethylene-insulated, polyvinylchloride-jacketed, shielded cable shall conform to NEMA WC 7 and AEIC CS5.

2.6.3 Cross-Linked Polyethylene with Interlocked Armor

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

Single-conductor, polyethylene-insulated, polyvinylchloride-jacketed, shielded cable with interlocked armor shall conform to NEMA WC 7 and AEIC CS5.

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

2.6.4 Ethylene-Propylene-Rubber-Insulated with PVC Jacket

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

Single conductor 15 KV cable assemblies shall 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.

Single-conductor, ethylene-propylene-insulated, polyvinylchloride-jacketed, shielded cable shall conform to NEMA WC 8 and AEIC CS6.

2.7 SINGLE-CONDUCTOR NONSHIELDED CABLES

2.7.1 Butyl Rubber with Neoprene Jacket

****

NOTE: Single-conductor, butyl-rubber-insulated, neoprene-jacketed, nonshielded cable should be specified for 2,400-volt phase-to-ground circuits (5,000-volt cable only).

****

Single-conductor, butyl-rubber-insulated, neoprene-jacketed, nonshielded cable shall conform to NEMA WC 3.

2.7.2 Cross-Linked Polyethylene

****

NOTE: Single-conductor, cross-linked polyethylene-insulated, nonshielded cable should be specified for 2,400-volt phase-to-ground circuits (5,000-volt cable or less).

****

Single-conductor, cross-linked polyethylene-insulated, nonshielded cable shall conform to NEMA WC 7 and AEIC CS5.

2.7.3 Ethylene-Propylene-Rubber-Insulated with PVC Jacket

****

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

****

Single-conductor, ethylene-propylene-rubber-insulated, polyvinylchloride-jacketed, nonshielded cable shall conform to NEMA WC 8 and AEIC CS6.

2.8 PORTABLE CABLES

****

NOTE: Multiple-conductor, butyl-rubber-insulated, neoprene-jacketed, shielded portable cable should be specified 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.

****

Multiple-conductor, butyl-rubber-insulated, neoprene-jacketed, shielded portable cable shall be type SHD conforming to NEMA WC 3.

2.9 NONMETALLIC JACKET

2.9.1 Interlock Armored Cable

Nonmetallic, corrosion-resistant jacket over interlock-armored cable shall be [[thermoplastic black] [colored] [polyvinylchloride]] [black polyethylene] conforming to [NEMA WC 4] [NEMA WC 2] [NEMA WC 8].

2.9.2 Lead-Sheathed Cable

Nonmetallic, corrosion-resistant jacket over lead-sheathed cable shall be polyvinylchloride at least [2.8] [_____] millimeter [0.11] [_____] inch thick, conforming to NEMA WC 2. Cover shall fit tightly to the lead sheath and shall be coated with a slipper compound.

2.9.3 Terminations

Potheads shall be provided with grounding terminals and cast-[iron] [aluminum] bells and shall be 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

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

[Cable racks, cable tray supports and related fittings shall be UL listed [standard] [heavy]-duty nonmetallic [glass-reinforced nylon] [polycarbonate].]

PART 3 EXECUTION

3.1 INSTALLATION

Medium-voltage cables shall be installed in accordance with NFPA 70.

Cable shall be installed 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.

Cables shall be secured with heavy duty cable ties in existing or new trays mounted horizontally, where cable rests on tray bottom. Cable ties shall be installed at minimum of [3000] [_____] millimeter [10] [_____] foot intervals.

Cables shall be secured 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, a liquid PVC patch shall be applied to maintain the integrity of the coating. After the installation is complete, an inspection shall be performed to ensure the absence of voids, pinholes, or cuts.

Contractor shall ensure that all cable tray is properly secured and supported prior to installing new armored cable. Contractor shall 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 shall 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

Cable with paper insulation shall be moisture-tested before being pulled into underground ducts. Contractor shall 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

Blowers shall be provided to force fresh air into manholes or confined areas where free movement or circulation of air is obstructed. Waterproof protective coverings shall be available on the work site to provide protection against moisture while a splice is being made. Pumps shall be used to keep manholes dry during splicing operations. Under no conditions shall a splice or termination be made with the interior of a cable exposed to moisture. Conductor insulation paper shall be moisture-tested before the splice is made. A manhole ring at least [150] [_____] millimeter [6] [_____]-inches above ground shall be used around the manhole entrance to keep surface water from entering the manhole. Unused ducts shall be plugged and water seepage through ducts in use shall be stopped 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 02585S MEDIUM VOLTAGE UNDERGROUND POWER DISTRIBUTION.

****

Ducts shall be thoroughly cleaned before installation of power cables. A standard flexible mandrel shall be pulled through each duct to loosen particles of earth, sand, or foreign material in the line. Mandrel length shall be not less than [300] [_____] millimeter [12] [_____]-inches long and shall have a diameter 13 millimeter 1/2 inch less than the inside

diameter of the duct. A brush with stiff bristles shall then be pulled through each duct to remove the loosened particles. Brush diameter shall be the same as or slightly larger than the diameter of the duct.

3.1.4 Pulling Cables in Ducts, Manholes and Utility Tunnels

Medium-voltage cables shall be pulled into ducts and utility tunnels with equipment designed for this purpose, including power-driven winch, cable-feeding flexible tube guide, cable grips, and lubricants. A sufficient number of trained personnel and equipment shall be employed to ensure the careful and proper installation of the cable.

Cable reel shall be set up 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. Flexible tube guide shall be installed through the opening in a manner that will prevent the cable from rubbing on the edges of any structural member.

Pulling force for a cable grip on lead-sheathed cable shall not exceed [6700] [_____] newton per 650 square millimeter [1,500] [_____] pounds per square inch of sheath cross-sectional area. A dynamometer shall be used in the pulling line to ensure that the pulling force is not exceeded. Pulling force for a nonmetallic-sheathed cable shall 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

Cable shall be unreeled from the top of the reel. Payout shall be carefully controlled. Cable to be pulled shall 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].

Woven-wire cable grips shall be used to grip the cable end when pulling small cables and short straight lengths of heavier cables.

Pulling eyes shall be attached to the cable conductors to prevent damage to the cable structure.

Pulling eyes and cable grips shall be used together for nonmetallic sheathed cables to prevent damage to the cable structure.

Minimum bending radius shall be 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]

Cables shall be liberally coated with a suitable cable-pulling lubricant as it enters the tube guide or duct. Grease and oil lubricants shall be used only on lead-sheathed cables. Nonmetallic sheathed cables shall be covered with wire-pulling compounds when required which have no deleterious effects on the cable. Rollers, sheaves, or tube guides around which the cable is pulled shall conform to the minimum bending radius of the cable.

Cables shall be pulled 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 shall not be permitted. Pulling operations shall be stopped immediately with any indication of binding or obstruction and shall not be resumed until such difficulty is corrected. Sufficient slack shall be provided for free movement of cable due to expansion or contraction.

Cable splices made up in manholes or utility tunnels shall be firmly supported on cable racks as indicated. No cable splices shall be pulled in ducts. Cable ends shall overlap at the ends of a section to provide sufficient undamaged cable for splicing. Cables to be spliced in manholes or utility tunnels shall overlap the centerline of the proposed joint by not less than [600] [_____] millimeter [2] [_____] feet.

Cables cut in the field shall have the cut ends immediately sealed to prevent entrance of moisture. Nonleaded cables shall be sealed with rubber tape wrapped down to [75] [_____] millimeter [3] [_____] inches from the cable end. Rubber tape shall be cover-wrapped with polyvinylchloride tape. Lead-covered cables shall be sealed 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

Splices shall be made in manholes or tunnels except where cable terminations are specifically indicated. Splicing and terminating of cables shall be expedited to minimize exposure and cable deterioration.

Cables shall be terminated in potheads. Dry terminations with medium voltage pennants, preformed, and hand wrapped stress cones may be used for terminating cables. Potheads shall be provided 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.

Pothead terminations shall be field fabricated 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 shall include 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.

Cable splices shall be field fabricated 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. Cable splices in manholes shall be located 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 shall be installed on cable racks or by other approved methods which will minimize physical stress on the splice connections. Splices shall be supported at approximately the same elevation as the installed cable except where space limitations or existing cable length limitations make this method impractical or impossible.

All universal demountable splices shall be supported in such manner so as to minimize physical stress on the splice connections. Each cable end termination shall be supported 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. Cable end termination and cable shall be secured to the supports in such a manner as to prevent movement of termination or cable at the support. Saddle type supports shall be installed 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

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

Pothead bells or bodies shall be 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. Pothead [bell caps] [lids] for cables up to [130 square millimeter] [250 kc mils] [250 amperes] shall be cast [iron] [aluminum]; and for cables of larger size and higher current ratings shall be cast [aluminum] [bronze] [nonmagnetic metal casting]. [Bell caps] [Lids] shall have matching machined flanged surfaces for sealing with gasket and cap-screw connections.

Bushings shall be glazed wet-process electrical porcelain insulators, factory assembled and hermetically sealed to bell [cap] [lid].

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

Cable-entrance fittings shall be cast-bronze wiping-sleeve type for lead-covered cable, and cast-aluminum positive-sealed stuffing boxes for nonlead-covered cables. Conduit couplings and armor base fittings shall be cast iron.

Three-conductor potheads with a neutral stud and lug may be used in lieu of four-conductor potheads in four-wire grounded neutral systems.

Potheads shall be completely filled, 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. Pothead parts that do not carry current shall be grounded.

3.1.7 Single-Conductor Potheads

Single-conductor potheads shall be the hermetically sealed capnut type and shall be suitable for the type, size, and electrical characteristics of the cable specified. Potheads shall consist of cast bodies, bushings, cable connectors, lugs, and entrance fittings.

Pothead bodies shall be metal castings with mounting brackets, when required, pipe plugs for filling and vent holes, and machined flanged surface for cable-entrance fitting. Bodies shall be 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.

Bushings shall be glazed wet-process electrical porcelain insulators, factory assembled and hermetically sealed to the pothead body.

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

Potheads shall be completely filled, 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. Pothead parts that do not carry current shall be grounded.

3.2 FIELD TESTING

Each shall be subjected 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.

Test equipment, labor, and technical personnel shall be provided as necessary to perform the electrical acceptance tests.

Arrangements shall be made to have tests witnessed and approved by the Contracting Officer.

Each power-cable installation shall be completely isolated from extraneous electrical connections at cable terminations and joints. Safety precautions shall be observed.

Each power cable shall first be given a full dielectric-absorption test with 5000-volt insulation-resistance test set. Test shall be applied for a long enough time to fully charge the cable. Readings shall be recorded every 15 seconds during the first 3 minutes of test and at 1 minute intervals thereafter. Test shall continue until three equal readings, 1 minute apart, are obtained. Minimum reading shall be 200 megohms at an ambient temperature of 20 degrees C 68 degrees F. Readings taken at other than 20 degrees C 68 degrees F ambient temperatures shall be corrected accordingly.

Upon successful completion of the dielectric absorption tests, the cable shall be subjected to a direct-current high-potential test for 5 minutes with test voltages applied in accordance with AEIC CS1 and IEEE Std 400 for paper-impregnated, lead-covered cable; AEIC CS5 and IEEE Std 400 for cross-linked, polyethylene-insulated cable; and AEIC CS6 and IEEE Std 400 for ethylene propylene rubber-insulated cable.

Leakage current readings shall be recorded 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, the test shall be immediately terminated and steps taken to find and correct the fault. When a second test becomes necessary, this test procedure shall be repeated.

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

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

Test data shall be recorded and shall include identification of cable and location, megohm readings versus time, leakage current readings versus time, and cable temperature versus time.

Final acceptance shall depend upon the satisfactory performance of the cable under test. No cable shall be energized until recorded test data have been approved by the Contracting Officer Final test reports shall be provided to the Contracting Officer. Reports shall have 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."

Radiographic tests shall be performed on all potheads at the discretion of the Contracting Officer to determine if voids exist in the pothead. Unacceptable terminations shall be reworked at no additional expense to the Government.

-- End of Section --