**********

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

**NASAKSC-26 05 13.00 98 (August 2012)**

---

**Preparing Activity: NASA**

**Superseding**
**NASAKSC-26 05 13.00 98 (November 2011)**

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated July 2023**

**********

SECTION 26 05 13.00 98

MEDIUM VOLTAGE CABLES
**08/12**

**********

**NOTE: This specification covers the requirements for medium voltage cables, including 5 kV and 15 kV shielded single-conductor power cables, cable splices and terminations, potheads, and fireproofing cables in manholes.**

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

**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.**

**Recommended changes to a NASAKSC Master Specification Section should be submitted as a Criteria Change Request (CCR) to the appropriate Technical Proponent (TP) through the SpecsIntact Help Desk.**

**********

PART 1 GENERAL

**********

**NOTE: If Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL and Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS are not included in the project specification, insert applicable requirements there from and delete the following**

**paragraph.**
**********

Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL and 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 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 CS8 | (2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM B8 | (2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft |
| ASTM D746 | (2014) Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact |

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

| | |
|---|---|
| IEEE 48 | (2020) Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV |

| | |
|---|---|
| IEEE 386 | (2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV |
| IEEE 400.2 | (2013) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF) |
| IEEE 404 | (2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V |

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

| | |
|---|---|
| ICEA S-94-649 | (2021) Concentric Neutral Cables Rated 5 Through 46 KV |

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

| | |
|---|---|
| NETA ATS | (2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems |
| NETA MAINT | (2011) Standard for Maintenance Testing Specifications for Electric Power Distribution Equipment and Systems |

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

| | |
|---|---|
| ANSI C119.1 | (2016) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts |

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

| | |
|---|---|
| NFPA 70 | (2023) National Electrical Code |
| NFPA 70E | (2024) Standard for Electrical Safety in the Workplace |

## 1.2 DEFINITIONS

Medium voltage power cables means all cables rated above 601 to 35,000 volts.

## 1.3 ADMINISTRATIVE REQUIREMENTS

### 1.3.1 Pre-Installation Meetings

No later than [30] [_____] days of Contract Award, the Contracting Officer will schedule a pre-installation meeting. Submit the following for review and approval prior to the meeting:

a. Pulling Plan including calculations of pulling tension and side wall pressure anticipated, and the maximum allowable pulling tension for each pull. Do not perform any pull until Government reviews and approves the pulling plan.

b. Splicer/Terminator Certifications

c. List of Splices and Terminations to be Installed by Splicer/Terminator

d. Manufacturer's catalog data for the following items:

(1) Single Conductor 5 kV Shielded Cable

(2) Single Conductor 15 kV Shielded Cable

(3) Cable Supports and Fittings

(4) Cable Tags

(5) Fireproof Tape

(6) Splice Kits (including splice grounding and manufacturer's recommended installation tools)

(7) Terminations

e. Certificates for the following showing that the cable manufacturer has made factory-conducted tests on each shipping length (reel) of cable. Include certified copies of test data showing conformance with the referenced standards and approval prior to delivery of cable.

(1) Conductor Resistance

(2) Accelerated Water Absorption Test

(3) Water Immersion Test

(4) Ionization

(5) High-Voltage

(6) Partial Discharge Test

(7) Qualification Test Reports

1.4 SUBMITTALS

**********

**NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project.**

**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.**

**An "S" following a submittal item indicates that the submittal is required for the Sustainability**

**Notebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.**

**********

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

SD-01 Preconstruction Submittals

List of Splices and Terminations to be Installed by Splicer/Terminator[; G]

SD-02 Shop Drawings

Pulling Plan[; G]

SD-03 Product Data

Single Conductor 5 kV Shielded Cable[; G]

Single Conductor 15 kV Shielded Cable[; G]

Cable Supports and Fittings[; G]

Cable Tags[; G]

Fireproof Tape[; G]

Splice Kits[; G]

Terminations[; G]

SD-06 Test Reports

Field Testing[; G]

KSC Medium Voltage Cable Test Form[; G]

Qualification Test Reports[; G]

Radiographic Tests[; G]

SD-07 Certificates

Factory-Conducted Tests on Each Shipping Length (Reel) of Cable[; G]

Splicer/Terminator Certifications[; G]

Conductor Resistance[; G]

Accelerated Water Absorption Test[; G]

Water Immersion Test[; G]

Ionization[; G]

High-Voltage[; G]

Partial Discharge Test[; G]

Qualification Test Reports[; G]

SD-08 Manufacturer's Instructions

Single Conductor 5 kV Shielded Cable[; G]

Single Conductor 15 kV Shielded Cable[; G]

Terminations[; G]

Splice Kits[; G]

SD-11 Closeout Submittals

List of Splices and Terminations to be Installed by Splicer/Terminator[; G]

## 1.5 QUALITY ASSURANCE

### 1.5.1 Qualifications`

Verify personnel performing Medium Voltage (MV) splicing or terminations have 5 years minimum experience in cable splicing and terminations of the type used in this project. In addition, submit splicer/terminator certifications issued by the cable splice and termination manufacturer who has examined and tested a test splice or termination of each type required by this contract for each cable splicer. Ensure the certification identifies which splices and terminations it applies to. Require each individual, certified or not, with the required 5 years medium voltage splicing and terminating experience, who is to perform cable splicing or terminating, to perform a minimum of one splice or termination of each type in the presence of the manufacturer's[ and Government's representative at Kennedy Space Center]. Supply all materials and tools required for the demonstration splices and terminations. Submit each splice or termination performed by individuals without manufacturer's certification to the manufacturer for testing and subsequent certification. Proof of certification will be verified by the [NASA] [_____] Contracting Officer's Technical Representative prior to installation of any splices or terminations. Certification is not required for load break elbows and dead break connectors.

Once a splice or termination has been started by a splicer, ensure the same splicer completes that particular splice, and that each termination and splice is started and completed in one continuous work period.

Maintain and submit a list of splices and terminations to be installed by splicer/terminator. Ensure the list includes the following for each splice or termination completed, and if a splice or termination fails after energizing, then the splicer/terminator making the splice is required to be recertified on the type that failed by the manufacturer prior to making any such future splices or terminations at KSC.

a. Name of splicer/terminator.

b. Date splice or termination was performed.

c. Location of splice or termination. For terminations at equipment indicate equipment number as required to completely define the location.

d. Feeder number.

## 1.6 DELIVERY, STORAGE, AND HANDLING

### 1.6.1 Shipping

Ship the cable on reels in such a manner that the cable is protected from mechanical injury. Hermetically seal every cable end of each length using heat-shrinkable molded cable end caps to exclude moisture and securely attached to the reel.

Ensure the minimum diameter of the reel drum is 14 times the overall diameter of the cable. For reels less than 1524 millimeters 60 inches in diameter, provide arbor holes sized for 65 millimeters 2-1/2 inches spindles; for those greater than 1524 millimeters 60 inches in diameter, provide arbor holes sized for 76 millimeters 3 inch spindles. Ensure reel sizes accommodate reel lengths specified in the purchase order, and that each reel contains only one length of cable cut to order.

Provide each reel with an arrow and appropriate wording, stenciled in plain view on each side, indicating proper rotation of reels. Plainly mark each reel on each side, and attach a tag to the cable end inside the lagging, stating the following information:

a. Purchaser's order number

b. Complete description of cable including manufacturer, cable size, voltage rating, percent insulation rating, insulating material, conductor size(s), year of manufacture

c. Actual shipping cable (reel) length

d. Reel number (e.g. 2 of 10)

e. Gross weight (i.e. with reel) and net weight (i.e. cable only)

Ship reels in a vertical position, sufficiently blocked in the bed of shipping vehicle to preclude movement.

# PART 2 PRODUCTS

## 2.1 CONDUCTORS

### 2.1.1 Material

Provide annealed copper core (phase) conductor material in accordance with ASTM B8.

### 2.1.2 Stranding

Provide Class B stranded conductors.

## 2.2 CABLE IDENTIFICATION

Provide cables with printing on the outer jacket showing the cable type, name of the manufacturer, the year in which the cable was manufactured, sequential cable reel length markings and a unique number for identification purposes. Closely group the information on the tape at 1.8 meters 6 foot maximum intervals to permit complete identification.

## 2.3 15 KV CABLES

**********

**NOTE: Due to the high available fault currents on Kennedy Space Center's 5 kV and 15 kV systems, minimum conductor and concentric neutral sizes are required. For most areas of KSC, use at least No. 4/0 AWG with full neutral or 350 kcmil with 1/3-neutral. Areas far from supply substations can use smaller cable sizes. Specify 12.7 cm 5-inch minimum conduit size.**

**********

### 2.3.1 General; 15 kV Cable

Provide single conductor 15 kv shielded cable assemblies consisting of:

a. Conductor core described above, an extruded semiconductor shield over the conductors

b. 5.59 millimeter 220 mils of ethylene-propylene-rubber (EPR) insulation

c. An extruded semiconductor insulation shield, a concentric neutral

d. A polyethylene (PE) jacket.

Ensure cable is rated for minimum 90 degrees C 194 degrees F continuous conductor temperature and 130 degrees C 266 degrees F emergency overload.

Provide single-conductor, ethylene-propylene-insulated, polyethylene-jacketed, shielded cable conforming to ICEA S-94-649 and AEIC CS8.

### 2.3.2 15 kV Cable Conductor Shielding

Provide conductors with a stress control layer consisting of extruded material applied between the conductor and the insulation to form a conductor shield (strand screen). Ensure material has proven long-term chemical compatibility with both the conductor and overlying insulation materials, and that the stress control layer meets the electrical and physical requirements of ICEA S-94-649.

### 2.3.3 Insulation; 15 kV Cable

Provide ozone resistant insulation material, of extruded thermosetting ethylene-propylene based polymer, capable of withstanding the continuous and emergency overload temperature ratings of the conductor.

2.3.4 Non-metallic Insulation Shield; 15 kV Cable

Provide extruded insulation shield made of an extruded thermoset material compatible with the insulation and jacket. Ensure insulation shield is applied directly over and bonded to the insulation, and complies with AEIC CS8.

2.3.5 Concentric Neutral Shield; 15 kV Cable

Provide copper wires helically applied over the insulation shield, where the minimum total cross sectional area (of the shield wires) is 1/3 of the core conductor for 350 kcmil cable, and full core conductor for 4/0 cable. Minimum size of an individual shield wire is 1.6 millimeter No. 14 AWG.

2.3.6 Jacket; 15 kV Cable

Provide polyethylene jacketed cable (PE) extruded over the concentric neutral to a minimum thickness of 2 millimeter 80 mils.

2.4 5 KV CABLES

**********

**NOTE: Due to the high available fault currents on Kennedy Space Center's 5 kV and 15 kV systems, minimum conductor and concentric neutral sizes are required. For most areas of KSC, use at least No. 4/0 AWG with full neutral or 350 kcmil with 1/3-neutral. Areas far from supply substations can use smaller cable sizes. Specify 12.7 cm 5-inch minimum conduit size.**

**********

2.4.1 General; 5 kV Cables

Provide single conductor 5 kv shielded cable assemblies consisting of:

a. Conductor core described above, an extruded semiconductor shield over the conductors

b. 2.92 millimeter 115 mils of ethylene-propylene-rubber (EPR) insulation

c. An extruded semiconductor insulation shield, a concentric neutral

d. A polyethylene (PE) jacket.

Ensure the cable is rated for minimum 90 degrees C 194 degrees F continuous conductor temperature and 130 degrees C 266 degrees F emergency overload.

Provide single-conductor, ethylene-propylene-insulated, polyethylene-jacketed, shielded cable conforming to ICEA S-94-649 and AEIC CS8.

2.4.2 5 kV Cable Conductor Shielding

Provide conductors having a stress control layer consisting of extruded material applied between the conductor and the insulation to form a conductor shield (strand screen). Ensure material has proven long-term

chemical compatibility with both the conductor and overlying insulation materials, and meets all electrical and physical requirements of ICEA S-94-649.

2.4.3 Insulation; 5 kV Cable

Provide insulation material which is ozone resistant, extruded thermosetting ethylene-propylene based polymer, and capable of withstanding continuous and emergency overload temperature ratings of the conductor.

2.4.4 Non-metallic Insulation Shield; 5 kV Cable

Provide extruded insulation shield made of an extruded thermoset material compatible with the insulation and jacket. Ensure insulation shield is applied directly over and bonded to the insulation, and complies with AEIC CS8.

2.4.5 Concentric Neutral Shield; 5 kV Cable

Provide copper wires helically applied over the insulation shield. Minimum total cross sectional area of the shield wires is 1/3 of the core conductor for 350 kcmil cable, and full core conductor for 4/0 cable. Minimum size of an individual shield wire is 1.6 millimeter No. 14 AWG.

2.4.6 Jacket; 5 kV Cable

Provide polyethylene jacket (PE) extruded over the concentric neutral to a minimum thickness of 2 millimeter 80 mils.

2.5 INSULATED MEDIUM VOLTAGE CONNECTORS

Provide connector with a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material per IEEE 386. Ensure connections are compatible with equipment bushings. Provide connectors as follows:

a. 200 Ampere loadbreak connector ratings: Voltage: 15kV, 95kV BIL. Short time rating: 10,000 amperes rms, symmetrical for a time duration of 0.17 seconds.

b. 600 Ampere deadbreak connector ratings: Voltage: 15kV, 95kV BIL. Short time rating: 27,000 ampere rms, symmetrical for a time duration of 4.0 seconds.

c. Provide connectors with a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material per IEEE 386. [Provide hot line voltage indicators on all connectors.]

Ensure connections are compatible with equipment bushings.

2.6 SPLICES

Provide splice kits which are the product of a single manufacturer, meeting the requirements in the paragraph entitled, "Splices and Terminations," of this section.

Provide splices for 15 kV EPR cable specifically designed for NASA cable and grounding provisions which include but are not limited to the

following:

a. Inner heat shrink stress control tube with external end sealant, additional heat shrink tube over inner tube and inner tube end sealant.

b. Heat shrink outer wraparound sleeve with heat sensitive indications on both the tube and rail/channel area to indicate proper torch heating, stress relief material, mastic, sealant, shielding mesh, and silicone grease.

2.7 TERMINATIONS

Provide Class 1 terminations per IEEE 48.

**********
**NOTE: Coordinate the following paragraph with Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION if Section 33 71 02 is used in this project.**
**********

2.8 CABLE SUPPORTS AND FITTINGS

[ Provide cable supports, related fittings, and accessories for use in corrosive underground locations, such as manholes, with a factory applied coating of polyvinylchloride of at least [0.51] [_____] millimeter [20] [_____] mils thick. Ensure polyvinylchloride (PVC) coated items have a uniform thickness and are free of blisters, breaks, and holidays. Use PVC compound conforming to ASTM D746.

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

]2.9 CABLE TAGS IN MANHOLES AND AT TERMINATIONS

Provide tags for each cable or wire located in manholes and at each termination. Place tags on all cables indicated to have tags.

2.9.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 31 MPa4500 pounds per square inch, and are 0.9 millimeter 0.035-inch thick, non-corrosive non-conductive. Ensure tags are resistive to acids, alkalis, organic solvents, salt water, and are distortion resistant to 150 degrees C300 degrees F. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ensure ties have a minimum loop tensile strength of 780 newtons 175 pounds. Provide cable tags with block letters, numbers, and symbols 25 millimeter 1 inch high on a yellow background. Ensure letters, numbers, and symbols do not fall off or change positions regardless of the cable tags orientation.

2.10 FIREPROOF TAPE

Provide fireproof tape approximately 0.8 millimeter 30 mils thick by 76 millimeters 3 inches wide, consisting of a flexible, unsupported elastomer that expands in fire to provide a thick char buildup between the flame and the cable. Ensure the tape does not give off a smoke when subjected to flames or support combustion. Also, ensure tape does not deteriorate when subjected to oil, water, gases, salt water, sewage and fungus.

## 2.11 FACTORY TESTING

Submit certified evidence that the cable manufacturer has made factory-conducted tests on each shipping length (reel) of cable. Submit certified copies of test data in accordance with applicable provisions of the referenced standard. Include in tests on each length of cable, conductor resistance; ionization; high voltage; partial discharge test.[ Contracting Officer or designee has the option of witnessing required factory testing at no additional cost. Provide a schedule of manufacturing and testing in advance to permit such witnessing, if requested.]

Submit certified qualification test reports in accordance with AEIC CS8 made in accordance with the applicable referenced standards. Ensure certified copies of test data show conformance to the requirements of referenced standards and submit for approval prior to shipment of the cable.

Prior to manufacturing, provide data regarding degradation of proposed insulating material and cable performance due to water immersion test as specified in this specification to the Contracting Officer or designee. Indicate in information AC breakdown stress in kV/mm or V/mil versus immersion time. Ensure a complete description and condition under which cable was tested accompanies the test information. Submit an accelerated water absorption test.

# PART 3 EXECUTION

## 3.1 DEMOLITION OR CABLE CUTTING

Notify the Contracting Officer 14 working days prior to an outage for demolition or cable cutting of medium voltage electrical system.

The Government has established a mandatory inspection point prior to Contractor performing any medium voltage cable cuts or demolition. Notify the Contracting Officer 48 hours in advance of this mandatory inspection point.

As part of the mandatory inspection point, positively identify and label the medium voltage cable to be worked utilizing an electronic cable identifier. Ensure the process of identifying and labeling the cable to be worked is witnessed by the Government. Cable cutting and demolition of any medium voltage cable can occur only after approval by the Contracting Officer.

## 3.2 INSTALLATION

Install medium-voltage cables in accordance with NFPA 70, and NFPA 70E.

[ Refer to contract provisions for safety submittals and requirements associated with working in the vicinity of energized cables and equipment. The use of arc-flash and shock prevention equipment and personal protective equipment is mandatory.

] Notify the Contracting Officer 14 working days prior to an outage that requires testing for phasing and phase rotation of 15 KV medium voltage electrical systems. The [Institutional Services Contractor(ISC)][_____] will identify and tag the phasing of equipment and provide to the

Contractor, in writing, the results of phasing and phase rotation tests. The Contractor is responsible for maintaining the phasing and phase rotation tests, and is responsible for maintaining the phasing, and matching the existing phase rotation and phasing when installing conductors in existing electrical systems.

Install the cables in the following locations:

Exterior:

a. In underground duct banks

b. In conduit above and below grade

c. In manholes

d. And by direct burial

Inside Buildings:

a. By open wire method

b. On insulator hooks

c. On racks

d. In wall and ceiling mounted cable trays

Installed cable or conductors of a primary distribution system will be rejected by the Government when placed:

a. Openly in cable trays or openly racked along interior walls

b. In the same raceway or conduit with AC/DC control circuits or AC power circuits operating at less than 600 volts

c. In a manner allowing the cable to support its own weight

3.2.1 Protection During Splicing Operations

Provide blowers to force fresh air into manholes or confined areas where free movement or circulation of air is obstructed. Ensure waterproof protective coverings are 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. Under no conditions, 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.

3.2.2 Duct Cleaning

**********

**NOTE: Delete the title and the following paragraph if the installation of power cables is in ducts and manholes provided under this project. Provisions for cleaning new duct are adequately covered in**

**Section 33 71 02 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.

3.2.2.1 PVC Duct

Ensure mandrel length is not less than 300 millimeters 12 inches long and has a diameter 13 millimeters 1/2 in less than the inside diameter of the duct. Pull a stiff bristled brush through each duct to remove the loosened particles. Ensure brush diameter is the same or slightly larger than the diameter of the duct.

3.2.2.2 Existing Fiber (Orangeburg) Duct

Push rod through duct. Pull a series of four 50 millimeters 2 inch wire brushes back and forth through the duct. Progressively increase the size of the four wire brushes until four 100 millimeters 4 inch wire brushes can be pulled back and forth, and all of the debris has been removed. Next pull a flexible mandrel with two 100 millimeters 4 inch heavy duty wire brushes on each side through the duct. Ensure mandrel is not less than 300 millimeters 12 inches long, and has a diameter that is 13 millimeters 1/2 inchto 25 millimeters 1 inch less than the inside diameter of the duct. Next, pull a 1.5 meters 5 foot section of sample cable, equivalent to what is being used. Make the final cable pull on the same day the sample cable was pulled.

3.2.3 Pulling Cables in Ducts and Manholes

3.2.3.1 Pulling Procedures

Pull medium-voltage cables into ducts with equipment designed for this purpose, including power-driven winch, jamb skid, cable-feeding flexible tube guide, long radius quadrant block cable pulling sheaves, pulling eyes, and lubricants. Employ a sufficient number of trained personnel and equipment with two-way radio communication capability 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 a flexible tube guide through the opening in a manner that prevents the cable from rubbing on the edges of any structural member (manhole frame, chimney, duct, etc.).

Use two long-radius 760 millimeter 30 inches minimum quadrant block cable pulling sheaves and necessary jamb skid support at the pulling end to ensure that sidewall pressures during pulling is not excessive. Use a dynamometer in the pulling line to ensure that the pulling force is not exceeded. Ensure the pulling force does not exceed the smaller of: allowable tension on pulling device, allowable tension on cable, or the tension which produces the allowable sidewall pressure. The allowable tension on the pulling device is 28,900 newtons 6500 pounds for pulling eyes [and 4400 newtons 1000 pounds for pulling grip (where allowed)]. Do not exceed the allowable tension on cable, using the allowable tension value computed from the following equation:

TM =0.036 X N X CM

Where: TM = maximum allowable pulling tension in newtons pounds

N = number of conductors in the cable

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

3.2.3.2 Allowable Sidewall Pressure

The allowable sidewall pressure is the smaller of 7300 newtons per meter 500 pounds per foot of bend radius or the cable manufacturer's recommended maximum value. Show in the pulling plan submittal the calculations for allowable tension and sidewall pressure as well as the anticipated tension and sidewall pressure for each pull in the project.

Unreel cable from the top of the reel, carefully controlling payout. Attach cable to be pulled through a swivel to the main pulling wire by means of a [pulling eye installed by the factory or approved cable splicer] [suitable cable grip permitted only on cables less than 60 meter 200 feet long and less than 50 millimeter 2 inches in diameter].

Attach pulling eyes to the cable conductors of the 3-1/C circuit to prevent damage to the cable structure. Pull the entire 3-1/C circuit simultaneously.

3.2.3.3 Minimum Bending Radius

Minimum bending radius during cable pulling operations is 760 millimeter 30 inches. For permanent cable bending/racking the minimum bending radius is 12 times cable diameter.

3.2.3.4 Coating of Cables

Liberally coat cables with a suitable cable-pulling lubricant as it enters the tube guide or duct. Do not use greaser and oil lubricants. Cover nonmetallic sheathed cables with wire-pulling compounds, when required, which have no deleterious effects on the cable. Use rollers, sheaves or tube guides, around which the cable is pulled, conforming to the 760 millimeter 30 inches minimum bending radius of the cable during the pulling operations.

3.2.3.5 Pulling Speed

Pull cables into ducts at a speed not to exceed [15] [_____] meters per minute 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 be 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.

3.2.3.6 Cable Splice Support And Sealing

Firmly support cable splices made up in manholes 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. Overlap cables to be spliced in manholes to the centerline of the proposed joint by not less than [600] [_____] millimeters 2 feet.

Immediately seal cut ends of cables cut in the field to prevent entrance of moisture with heat-shrinkable molded cable end caps.

3.2.4 Splices and Terminations

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

Make splices in manholes or direct buried cable as shown on the drawings. Make cable terminations at equipment specifically indicated. Expedite splicing and terminating of cables to minimize exposure and cable deterioration.

Field fabricate cable splices from pre-molded or heat-shrinkable 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.

Use only equipment and materials recommended by the splice manufacturer including calibrated cutting equipment to ensure consistent cut depths when preparing cable ends for the application of the splice kit. Connect the cable concentric neutral/shield wires across one side of the splice by split bundling the splice neutral wiring and connecting each bundle set to a continuous No. 4 AWG solid bare copper conductor via two compression conductors. Ensure the No. 4 AWG conductor extrudes from the cable splice jacket and connects to the manholes grounding system. Make all connections within the splice utilizing long barrel-type compression connectors and appropriate compression tools with proper size dies to ensure a satisfactory mechanical and electrical joint. Ensure bare connections of concentric neutral/shield wires are either contained within the splice kit or sealed via an additional outer covering,consisting of a heavy wall, heat-shrinkable tubing containing adhesive material (mastic) that melts as heat is applied and the outer tubing shrinks to form a moisture proof environmental seal. Provide outer tubing conforming to ANSI C119.1. Ensure splice meets the requirements of IEEE 404 for a 15 kV rating and is rated by the manufacturer for use on 15 kV class feeder cable systems. Take extra precautions to seal around the exit area of the bare copper jumpers with an additional mastic per the splice manufacturer's recommendations.

Terminate cables in approved cable terminations, rated Class 1 per IEEE 48. Dry terminations with medium voltage pennants, preformed, and hand wrapped stress cones can be used for terminating cables. Provide terminations with adequate means for making external connections to the cable conductors of single-conductor cables (phase and concentric neutral), protecting the cable insulation against moisture, oil, or other contaminants. Take extra precautions in physically protecting and supporting cables, and maintaining the insulation level of the cable.

Include in installation 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.

Install cable splices on cable racks or by other approved methods which minimizes 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.

3.2.5 Fireproofing

Provide fireproofing (Arc Proofing) for individual cable conductor in manholes, handholes and vaults which carry current at 2200 volts or more.

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Extend the tape 25 millimeter 1 inch into the ducts. To prevent unraveling, random wrap the fireproofing tape the entire length of the fireproofing with pressure-sensitive glass cloth tape.

3.2.6 Cable Tag Installation

Install cable tags in each manhole and at each termination as specified. Install cable tags over the fireproofing and position the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes and equipment.

**********

**NOTE: Although NETA ATS, NETA MAINT and referenced standards indicate higher DC High Potential test voltages, KSC has elected to use the values shown below.**

**********

3.3 FIELD TESTING

After the installation of power cables has been completed, including splices, joints, and terminations, and before the cable is energized, subject each medium voltage cable to field testing in accordance with the following requirements:

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

b. Obtain a KSC medium voltage cable test form from the Contracting Officer prior to commencing Field Testing. Record all tests on forms provided, and submit completed forms to the Contracting Officer.

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

d. Isolate each power-cable installation completely from extraneous electrical connections at cable splices/terminations and joints. Observe all safety precautions.

e. Ensure each power cable is first given an insulation resistance test using a meg-ohmmeter with a voltage output of at least 2,500-volts. Apply test for a long enough time to fully charge the cable (no less than one minute). Record readings as indicated on forms provided. The minimum reading is 5000 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 accordingly.

f. Conform testing to NETA ATS, and NETA MAINT.

Upon successful completion of the insulation resistance test, subject the cable to a Very Low Frequency (VLF) AC high potential test. Adhere general VLF testing measures, parameters, considerations, and results to the following:

a. Ensure test voltage duration is continuous duty for 30 minutes (non-interrupted)

b. Provide the test equipment to test the cable capacity in microfarads and record on the KSC Medium Voltage AC Hi-pot test form (VLF).

c. Provide the test equipment to generate the test voltages required for the 30 minute test duration and adhere to the following table:

**VLF Test Voltage for Sinusoidal Waveform**

| Cable Rating phase to phase | Acceptance (phase to ground test values) | Acceptance (phase to ground test values) |
|---|---|---|
| | (New cable) | (Existing cable spliced to new cable) |
| (rms voltage, KV) | (peak voltage, KV) | (peak voltage, KV) |
| [5] | [14] | [10] |
| [15] | [28] | [22; (EPR TO EPR)] |
| [15] | [15] | [15; (EPR TO NON-EPR)] |

d. Ensure the sinusoidal test frequency is 0.1 Hertz.

e. Do not perform test on cable attached to equipment.

**********

**NOTE: Include, but do not limit Acceptance test values to peak voltage, frequency, and duration, with respect to the cable rating, and clearly identify each on the test submittal, with pass/fail results identified per cable installation (refer to IEEE 400.2). Notify Contracting Officer or Contracting Officer's Technical Representative 48 hours prior to test start. All testing will be witnessed by the Government.**

**********

Ensure Splices/terminations are clean, dry, and tested per IEEE 48 and IEEE 400.2.

Perform and submit radiographic tests on all splices/terminations at the discretion of the Contracting Officer to determine if voids exist. Rework unacceptable cable, splices or terminations at no additional expense to the Government.

-- End of Section --