****
USACE / NAVFAC / AFCEC / NASA **UFGS 33 71 02 (February 2014)**

Preparing Activity: NAVFAC **Superseding**
UFGS 33 71 02.00 20 (August 2008)
UFGS 33 70 02.00 10 (November 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2014
****

SECTION TABLE OF CONTENTS

DIVISION 33 - UTILITIES

SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION

02/14

-- End of Section Table of Contents --

****
USACE / NAVFAC / AFCEC / NASA | UFGS 33 71 02 (February 2014)

Preparing Activity: NAVFAC | Superseding
UFGS 33 71 02.00 20 (August 2008)
UFGS 33 70 02.00 10 (November 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2014
****

SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION
02/14

****
NOTE: This guide specification covers the requirements for underground electrical work.

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).
****

****
NOTE: This guide specification does not cover all possible methods or requirements for providing underground facilities. To do so would be to produce an involved, confusing document. This guide specification presents the usual methods and the most used alternatives. Different materials and methods, properly specified, indicated, and economically used will be acceptable when approved by cognizant authority.
****

****

Note: This section use the following manhole / handhole sketches.

NOTE: TO DOWNLOAD UFGS GRAPHICS

Go to http://www.wbdg.org/ccb/NAVGRAPH/graphtoc.pdf**.**

LIST OF SKETCHES

Sketches are available in metric (SI) and U.S. Customary (IP) system dimensions. Sketch titles and style numbers are unchanged for both types.

The metric values indicated are a conversion of the IP system dimensions.

Do not include list of sketches, or sketches themselves, in project specifications. Use manhole / handhole sketches as details on drawings whenever possible. If special features are required for a project, do not modify sketches, but indicate these changes on notes below the sketch. The "UG" style numbers and dates should remain on the drawing details.

SKETCH NUMBER	TITLE
UG - 1	Standard Electrical Manhole (Nontraffic), Types 1 and 2
UG - 2	Standard Electrical Manhole (Traffic), Types 3 and 4
UG - 3	Standard Electrical Manhole (Airfield), Types 5 and 6
UG - 4	Standard Electrical Handhole (Nontraffic),Types 1 and 2
UG - 5	Standard Electrical Handhole (Traffic/Airfield), Types 3 and 4
UG - 6	Standard Electrical Handhole (Nontraffic),(Composite/Fiberglass) Types 5, 6, 7, 8 and 9
UG - 7	Details (Pulling-In Irons, Cable Rack, and Duct Entrance)

****

NOTE: The following information must be shown on the project drawings:

1. Where specification identifies type, size, color, finish, or other definitive information to be "as indicated," include the information on the drawings.

2. Location of ducts, and cables.

3. Types of wire and cable; number and sizes of conductors.

4. Ground rods and ground girdles.

5. Special conditions, including live end caps and ductbank reinforcing, as required.

****

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

****

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

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

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 318M	(2011; Errata 2013) Building Code Requirements for Structural Concrete & Commentary
ACI SP-66	(2004) ACI Detailing Manual

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2007) specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B231/B231M	(2012) Standard Specification for Concentric-Lay-Stranded Aluminum 1350

	Conductors
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B400/B400M	(2008; E 2013) Standard Specification for Compact Round Concentric-Lay-Stranded Aluminum 1350 Conductor
ASTM B496	(2014) Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors
ASTM B609/B609M	(2012) Standard Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical purposes
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B800	(2005; R 2011) Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes-Annealed and Intermediate Tempers
ASTM B801	(2007; R 2012) Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation
ASTM C139	(2011) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C32	(2013) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C478	(2013) Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2013) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C857	(2014) Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM C990	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C990M	(2009; R 2014) Standard Specification for

	Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)
ASTM F2160	(2010) Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)
ASTM F512	(2012) Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2006; INT 1 2011) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE 400.2	(2013) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)
IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE 48	(2009) Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C135.30	(1988) Standard for Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013) National Electrical Safety Code
IEEE C37.20.3	(2013) Standard for Metal-Enclosed Interrupter Switchgear
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-94-649	(2013) Standard for Concentric Neutral Cables Rated 5 Through 46 KV

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing

	Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2011) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
ANSI/NEMA WC 71/ICEA S-96-659	(1999) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA C119.4	(2011) Electric Connectors - Connectors for Use Between Aluminum-to-Aluminum or Aluminum-to-Copper Conductors Designed for Normal Operation at or Below 93 Degrees C and Copper-to-Copper Conductors Designed for Normal Operation at or Below 100 Degrees C
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2013) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 6 & 8	(2013) Standard for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations
NEMA TC 7	(2013) Standard for Smooth-Wall Coilable Electrical Polyethylene Conduit
NEMA TC 9	(2004) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation
NEMA WC 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	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

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

THE SOCIETY OF CABLE TELECOMMUNICATIONS ENGINEERS (SCTE)

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

U.S. DEPARTMENT OF AGRICULTURE (USDA)

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

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

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

UNDERWRITERS LABORATORIES (UL)

UL 1072	(2006; Reprint Jun 2013) Medium-Voltage Power Cables
UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 44	(2014) Thermoset-Insulated Wires and Cables
UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013) Metallic Outlet Boxes
UL 514B	(2012) Conduit, Tubing and Cable Fittings
UL 6	(2007; reprint Nov 2010) Electrical Rigid Metal Conduit-Steel
UL 651	(2011; Reprint May 2014) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 83	(2014) Thermoplastic-Insulated Wires and Cables
UL 854	(2004; Reprint Sep 2011) Standard for Service-Entrance Cables

[1.2 SYSTEM DESCRIPTION

****

NOTE: Do not use this paragraph for Navy projects.

For Army projects, select the features and fill in blanks with selections appropriate for the design condition and in accordance with guidance contained in UFC 3-550-01, "Exterior Electrical Power Distribution".

See UFC 3-550-01 for guidance regarding service conditions. Retain or add the required conditions.

Provide seismic requirements, if a Government designer is the Engineer of Record, and show on the drawings. Delete the inappropriate bracketed phrase. Pertinent portions of UFC 3-310-04, "Seismic Design for Buildings" and Sections 13 48 00, SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 26 05 48.00 10, SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT properly edited, must be included in the contract documents.

****

Items provided under this section must be specifically suitable for the following service conditions. Seismic details must [conform to UFC 3-310-04, "Seismic Design for Buildings" and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT] [be as indicated].

a. Fungus Control [_____]

b. Altitude [_____] m feet.

c. Ambient Temperature [_____] degrees C F.

d. Frequency [_____]

e. Ventilation [_____]

f. Seismic Parameters [_____]

g. Humidity Control [_____]

h. Corrosive Areas [_____]

i. [_____]

]1.3 DEFINITIONS

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

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

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

****
NOTE: For Navy projects, areas subject to aircraft loading are generally defined as follows:

1. For fixed wing aircraft facilities:
a) On or within 61 m 200 feet of runway sideline
b) On or within 15 m 50 feet of taxiway or apron sideline
c) Within Type 1 clear zone area as defined by UFC 3-260-01, "Airfield and Heliport Planning and Design".

2. For rotary wing aircraft facilities:
On landing surfaces, primary surfaces, or within areas defined as "paved and unpaved shoulders" in UFC 3-260-01, "Airfield and Heliport Planning and Design".
****

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

]1.4 SUBMITTALS

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

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, 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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy 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 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

[Aluminum conductors[; G][; G, [_____]]]

[Submit modified drawings and engineering calculations associated with design changes required for use of aluminum conductors.]

Precast underground structures[; G][; G, [_____]]

SD-03 Product Data

****
NOTE: Submittals are required for each kind, voltage, or type used on the project.
****

Medium voltage cable[; G][; G, [_____]]

Medium voltage cable joints[; G][; G, [_____]]

Medium voltage cable terminations[; G][; G, [_____]]

[Live end caps[; G][; G, [_____]]

] Precast concrete structures[; G][; G, [_____]]

Sealing Material

Pulling-In Irons

Manhole frames and covers[; G][; G, [_____]]

Handhole frames and covers[; G][; G, [_____]]

[Frames and Covers for Airfield Facilities[; G][; G, [_____]]

][Ductile Iron Frames and Covers for Airfield Facilities[; G][; G, [_____]]

] Composite/fiberglass handholes[; G][; G, [_____]]

Cable supports (racks, arms and insulators)[; G][; G, [_____]]

****
NOTE: For Navy projects, do not use protective device coordination studies.
****

[Protective Devices and Coordination Study[; G][; G, [_____]]

][The study must be submitted with protective device equipment submittals. No time extension or similar contract modifications

will be granted for work arising out of the requirements for this study. Approval of protective devices proposed must be based on recommendations of this study. The Government must not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

] SD-06 Test Reports

Medium voltage cable qualification and production tests[; G][; G, [_____]]

Field Acceptance Checks and Tests; G

Arc-proofing test for cable fireproofing tape[; G][; G, [_____]]

****
NOTE: Use Cable Installation only when pulling cable between manholes; do not use for pulling from pole riser to manhole only.
****

[Cable Installation Plan and Procedure[; G][; G, [_____]]

][[Six][_____] copies of the information described below in 215.9 by 279.4 mm 8-1/2 by 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Separate sections by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

][a. Site layout drawing with cable pulls numerically identified.

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

][c. The cable manufacturer and type of cable.

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

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

][f. The actual cable pulling tensions encountered during pull.

] SD-07 Certificates

Cable splicer/terminator[; G][; G, [_____]]

Cable Installer Qualifications[; G][; G, [_____]]

[Directional Boring Certificate of Conformance[; G][; G, [_____]]

]1.5 QUALITY ASSURANCE

1.5.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings

for precast manholes and handholes bearing the seal of a registered professional engineer including:

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

b. Manufacturer's printed assembly and installation instructions

c. Design calculations

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

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

[1.5.2 Certificate of Competency for Cable Splicer/Terminator

****
NOTE: Delete this paragraph if there is no medium voltage work required for the project.
****

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

]1.5.3 Cable Installer Qualifications

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

[1.5.4 Directional Boring Certificate of Conformance

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

]1.5.5 Regulatory Requirements

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

advisory provisions of IEEE C2 and NFPA 70 unless more stringent requirements are specified or indicated.

1.5.6 Standard Products

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

1.5.6.1 Alternative Qualifications

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

1.5.6.2 Material and Equipment Manufacturing Date

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

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 15.75 kV per mm 400 volts per mil at 60 Hz, and tensile strength must be minimum 25 MPa 3500 psi.

2.1.2 Intermediate Metal Conduit

UL 1242.

2.1.2.1 Intermediate Metal Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 15.75 kV per mm 400 volts per mil at 60 Hz, and tensile strength must be minimum 25 MPa 3500 psi.

2.1.3 Plastic Conduit for Direct Burial

****

NOTE: Specify EPC-40-PVC or EPC-80-PVC for direct-burial and riser applications. Choose UL 651 where conduit is required to be in compliance with

NFPA 70 and for most applications. Choose NEMA TC 2 when conduit size is greater than 6 inches.
****

[UL 651,[Schedule 40][or][Schedule 80][as indicated]][NEMA TC 2,[EPC-40-PVC][or][EPC-80-PVC][as indicated].

]2.1.4 Plastic Duct for Concrete Encasement

****
NOTE: Specify EPC-40-PVC or EPC-80-PVC for transition to riser applications.

EB-20 and EB-35 both perform the same functions of providing a form for the concrete. Only EPC-20 is UL listed. Choose EB-35 where breakage during handling is a concern. Choose EPC-40-PVC where required for design loads or for activity requirements.
****

UL 651 and ASTM F512, [NEMA TC 6 & 8, Type EB-20-PVC][NEMA TC 6 & 8, Type EB-35-PVC][NEMA TC 2, Type EPC-40-PVC][or][as indicated].

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

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

]2.1.6 Innerduct

Provide corrugated [or solid wall] polyethylene (PE) or PVC innerducts, or fabric-mesh innerducts, with pullwire. Size as indicated.

2.1.7 Conduit Sealing Compound

Compounds for sealing ducts and conduit must have a putty-like consistency workable with the hands at temperatures as low as 2 degrees C 35 degrees F, must neither slump at a temperature of 150 degrees C 300 degrees F, nor harden materially when exposed to the air. Compounds must adhere to clean surfaces of fiber or plastic ducts; metallic conduits or conduit coatings; concrete, masonry, or lead; any cable sheaths, jackets, covers, or insulation materials; and the common metals. Compounds must form a seal without dissolving, noticeably changing characteristics, or removing any of the ingredients. Compounds must have no injurious effect upon the hands of workmen or upon materials.[Inflatable bladders may be used as an option.]

2.1.8 Fittings

2.1.8.1 Metal Fittings

UL 514B.

2.1.8.2 PVC Conduit Fittings

****
NOTE: Choose UL listed fittings for most applications and where conduit is required to comply

with NFPA 70.
****

[UL 514B, UL 651][NEMA TC 3].

2.1.8.3 PVC Duct Fittings

NEMA TC 9.

[2.1.8.4 Outlet Boxes for Steel Conduit

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

]2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

****
NOTE: In most cases NFPA 70 requires listed conductors and cable. Choose bracketed item for NEMA WC 70 only when compliance with NFPA 70 is not required.
****

Insulated conductors must be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements[, or in accordance with NEMA WC 70]. Wires and cables manufactured more than [24][12] months prior to date of delivery to the site are not acceptable. Service entrance conductors must conform to UL 854, type USE.

2.2.1 Conductor Types

****
NOTE: Allow aluminum conductors for new underground lines.
****

Cable and duct sizes indicated are for copper conductors and THHN/THWN unless otherwise noted. Conductors No. 10 AWG and smaller must be solid. Conductors No. 8 AWG and larger must be stranded.[Conductors No. 6 AWG and smaller must be copper. Conductors No. 4 AWG and larger may be either copper or aluminum, at the Contractor's option. Do not substitute aluminum for copper if the equivalent aluminum conductor size would exceed 500 kcmil. When the Contractor chooses to use aluminum for conductors No. 4 AWG and larger, the Contractor must: increase the conductor size to have the same ampacity as the copper size indicated; increase the conduit and pull box sizes to accommodate the larger size aluminum conductors in accordance with NFPA 70; ensure that the pulling tension rating of the aluminum conductor is sufficient; relocate equipment, modify equipment terminations, resize equipment, and resolve to the satisfaction of the Contracting Officer problems that are direct results of the use of aluminum conductors in lieu of copper.][All conductors must be copper.]

2.2.2 Conductor Material

****
NOTE: For project applications which require a different insulation than those listed below, reference a Government or industry standard that the

cable or conductor must meet. For projects which require multiple types of insulations, indicate the type for each cable on the project drawings. Refer to UFC 3-550-01, "Exterior Electrical Power Distribution" for further guidance.
****

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt,[Type THWN/THHN conforming to UL 83][or][Type[XHHW][or][RHW] conforming to UL 44]. Copper conductors must be annealed copper complying with ASTM B3 and ASTM B8.[Aluminum conductors must be Type AA-8000 aluminum conductors complying with ASTM B800 and ASTM B801, and must be of an aluminum alloy listed or labeled by UL as "component aluminum-wire stock (conductor material). Type 1350 is not acceptable. Intermixing of copper and aluminum conductors in the same raceway is not permitted.]

[2.2.3 Jackets

Multiconductor cables must have an overall PVC outer jacket.

][2.2.4 Direct Buried

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

]2.2.5 In Duct

****
NOTE: For Army and Air Force projects only, coilable plastic duct may be used as an alternative to direct burial where extra physical protection is required.
****

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

2.2.6 Cable Marking

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

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

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

ungrounded conductors in different voltage systems must be as follows:

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

b. 480/277 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

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

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

]2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

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

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

[b. For use with aluminum conductors: UL 486A-486B. For connecting aluminum to copper, connectors must be the circumferentially compressed, metallurgically bonded type.

]2.4 LOW VOLTAGE SPLICES

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

2.4.1 Heat Shrinkable Splice

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

2.4.2 Cold Shrink Rubber Splice

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

2.5 MEDIUM VOLTAGE CABLE

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and

Thousand Circular Mils (Kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than [24][12] months prior to date of delivery to the site are not acceptable. Provide single conductor type cables unless otherwise indicated.

2.5.1 Cable Configuration

****
NOTE: For Navy projects, use type MV only and delete requirements for concentric neutrals throughout.
****

****
NOTE: For Army and Air Force projects:

The two most commonly produced/specified medium voltage cables are Type MV (as described in UL 1072) and underground distribution ("UD/URD"), commonly used by electrical utilities. Type MV is a type designation recognized by NFPA 70 because it is UL listed. "UD/URD" is not a recognized type designation because it is utilized primarily by electrical utilities, who are not governed by NFPA 70 and for whom a UL listed cable adds unnecessary expense. Both type MV and "UD/URD" can be specified for use in duct or direct buried. In addition to the standard MV-90, NFPA 70 also lists an MV-105 temperature rating. However, MV-105 is not available from all manufacturers. Provide MV-105, only if needed.

Use either Type MV or "UD/URD" in ducts, keeping in mind that the concentric neutral affects bending radius and pulling tensions, therefore limiting the maximum pull and distance between manholes. Use "UD" for direct buried applications.

Choose 133 percent insulation level on 5 kV, 15 kV and 25 kV rated cables.
****

Provide [Type MV cable, conforming to NEMA WC 74/ICEA S-93-639 and UL 1072] [concentric neutral underground distribution cable conforming to ICEA S-94-649][metallic armored cables, consisting of three-conductor, multi-conductor cables, with insulation and shielding, as specified, using [a galvanized steel][an aluminum] interlocked tape armor and thermoplastic jacket]. Provide cables manufactured for use in[duct][or][direct burial] applications[as indicated]. Cable must be rated [5 kV][15 kV][25 kV][28 kV][35 kV][as indicated] with [100][133] percent insulation level.

2.5.2 Conductor Material

****
NOTE: Provide aluminum conductors for new underground circuits and extensions of existing

circuits. This includes all new medium voltage systems designs that do not require interface (splicing copper to aluminum in underground structures) with existing copper infrastructure. Refer to UFC 3-550-01, "Exterior Electrical Power Distribution" paragraph entitled "Underground Electrical Systems" for additional guidance.

****

****

NOTE: A concentric compressed conductor has a diameter that is 3 percent less than a regular concentric conductor. A compact conductor has a diameter that is 10 percent less than a regular concentric conductor. Edit to specify compact conductors where necessary to limit duct fill (i.e. where new conductors are installed in existing ducts).

****

Provide concentric-lay-stranded, Class B[compact round] conductors. Provide[aluminum alloy 1350 cables, 3/4 hard minimum complying with ASTM B609/B609M and ASTM B231/B231M for regular concentric and compressed stranding or ASTM B400/B400M for compacted stranding][soft drawn copper cables complying with ASTM B3 and ASTM B8 for regular concentric and compressed stranding or ASTM B496 for compact stranding].

2.5.3 Insulation

****

NOTE: For projects which require multiple types of insulations, or special types of cables, such as submarine cable, indicate the type for each cable on the project drawings. Choose XLP or tree retardant XLP for "UD or URD" cable and either XLP or EPR for Type MV cable.

Choose AEIC CS8, except for concentric neutral cable only, choose ICEA S-94-649.

****

Provide [ethylene-propylene-rubber (EPR) insulation conforming to the requirements of ANSI/NEMA WC 71/ICEA S-96-659 and [AEIC CS8][ICEA S-94-649]][tree-retardant cross-linked thermosetting polyethylene (XLP) insulation conforming to the requirements of NEMA WC 74/ICEA S-93-639 and [AEIC CS8][ICEA S-94-649]].

2.5.4 Shielding

****

NOTE: Choose tape shielding unless wire shielding is allowed or required by the Activity.

****

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

2.5.5 Neutrals

****
NOTE: Use first bracketed sentence for type MV cable and second bracketed sentence for type UD/URD cable.

In second bracketed sentence, select full ampacity concentric neutral for single-phase applications and one-third ampacity for three-phase applications.

Include the last bracketed sentence where high impedance grounded neutral systems are employed.
****

[Neutral conductors must be [copper][aluminum], employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable.][Concentric neutrals conductors must be copper, having a combined ampacity [equal to][1/3 of] the phase conductor ampacity rating.][For high impedance grounded neutral systems, the neutral conductors from the neutral point of the transformer or generator to the connection point at the impedance must utilize [copper][aluminum] conductors, employing the same insulation level and construction as the phase conductors.

]2.5.6 Jackets

****
NOTE: PVC is acceptable for duct applications. Polyethylene (LLDPE) is exceptional for direct burial and in duct applications where there is significant amounts of water. There are many other types of jacket materials available (neoprene, hypalon, thermoplastic CPE) for special environments involving exposure to sunlight, petroleum products, and corrosive chemicals. Consult local cable representatives to specify the appropriate jacket for the application.

Choose the last bracketed sentence when PVC is specified.
****

Provide cables with a [PVC][_____] jacket.[Direct buried cables must be rated for direct burial.][Provide type UD cables with an overall jacket.] [Provide PVC jackets with a separator that prevents contact with underlying semiconducting insulating shield.]

2.6 MEDIUM VOLTAGE CABLE TERMINATIONS

****
NOTE: Specification sections for equipment, such as pad-mounted transformers, SF-6 switches, and unit substations, contain paragraphs for terminations, and have not been updated to coordinate with this specification section. When this paragraph is used only for that equipment, specify terminations either in that section or in this section, and delete paragraph from the other section.

****

****

NOTE: Provide indoor terminator/outdoor terminations with skirts. By including skirts for "indoor" and "within equipment" locations, tracking resistance is significantly improved. Provision of skirts for indoor terminations automatically makes them IEEE 48 Class 1.

****

IEEE 48 Class 1; of the molded elastomer, prestretched elastomer, or heat-shrinkable elastomer. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations, where required, must be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Terminations must be provided in a kit, including: skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations must be the product of one manufacturer, suitable for the type, diameter, insulation class and level, and materials of the cable terminated. Do not use separate parts of copper or copper alloy in contact with aluminum alloy parts in the construction or installation of the terminator.

2.6.1 Cold-Shrink Type

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

2.6.2 Heat Shrinkable Type

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

[2.6.3 Separable Insulated Connector Type

****

NOTE: Coordinate the connector ratings required with the equipment specification for transformers and switches.

Separable connectors must not be used in manholes.

****

IEEE 386. Provide connector with steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material. Provide

connectors of the loadbreak or deadbreak type as indicated, of suitable construction for the application and the type of cable connected, and that include cable shield adaptors. Provide external clamping points and test points. Separable connectors must not be used in manholes/handholes.

[a. 200 Ampere loadbreak connector ratings: Voltage: [15 kV, 95 kV BIL][25 kV, 125 kV BIL][35 kV, 150 kV BIL]. Short time rating: 10,000 rms symmetrical amperes.
]

****
NOTE: For Navy projects, provide 200 ampere bushing interface on all 600 ampere connectors.
****

[b. 600 Ampere deadbreak connector ratings: Voltage: [15 kV, 95 kV BIL][25 kV, 125 kV BIL][35 kV, 150 kV BIL]. Short time rating: 25,000 rms symmetrical amperes.[Connectors must have 200 ampere bushing interface[for surge arresters][as indicated].]
]

****
NOTE: Include the following paragraph only when the activity requires additional grounding elbows and feed-thru inserts.
****

[c. Provide[[one][_____] set[s] of three grounding elbows][and][[one][_____] set[s] of three feed-thru inserts]. Deliver [grounding elbows][and][feed-thru inserts] to the Contracting Officer.

]]2.7 MEDIUM VOLTAGE CABLE JOINTS

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

2.7.1 Heat-Shrinkable Joint

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

2.7.2 Cold-Shrink Rubber-Type Joint

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

2.8 TELECOMMUNICATIONS CABLING

Provide telecommunications cabling in accordance with Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

[2.9 LIVE END CAPS

****
NOTE: Live end caps are only required when cable is required to remain unterminated, but energized. Live end cap locations must be indicated on the drawings.
****

Provide live end caps using a "kit" including a heat-shrinkable tube and a high dielectric strength, polymeric plug overlapping the conductor. End cap must conform to applicable portions of IEEE 48.

]2.10 TAPE

2.10.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.10.2 Buried Warning and Identification Tape

****
NOTE: For Navy projects, use Section 31 23 00.00 20, EXCAVATION AND FILL.
****

Provide detectable tape in accordance with Section [31 23 00.00 20 EXCAVATION AND FILL][31 00 00 EARTHWORK].

2.10.3 Fireproofing Tape

****
NOTE: Provide the following paragraph where medium voltage cable (2200 volts or greater) is installed in manholes, handholes and vaults.
****

Provide tape composed of a flexible conformable unsupported intumescent elastomer. Tape must be not less than 0.762 mm .030 inch thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, and must not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.11 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of 890 N 200 pounds.

2.12 GROUNDING AND BONDING

2.12.1 Driven Ground Rods

Provide [copper-clad steel ground rods conforming to UL 467] [zinc-coated steel ground rods conforming to IEEE C135.30] [solid stainless steel ground rods] not less than [19 mm 3/4 inch] in diameter by [3.1 m 10 feet] in length. Sectional type rods may be used for rods 20 feet or longer.

2.12.2 Grounding Conductors

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

2.13 CAST-IN-PLACE CONCRETE

****

NOTE: Use the first bracketed paragraph when project includes a concrete section in Division 3; otherwise, the second bracketed paragraph may be used. Coordinate requirements with Section 03 30 00 CAST-IN-PLACE CONCRETE for Navy projects and with 03 30 00.00 10 CAST-IN-PLACE CONCRETE for Army projects.

****

Provide concrete in accordance with Section [03 30 00 CAST-IN-PLACE CONCRETE] [03 30 00.00 10 CAST-IN-PLACE CONCRETE]. In addition, provide concrete for encasement of underground ducts with 20 MPa 3000 psi minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts must be 30 MPa 4000 psi minimum 28-day compressive strength unless specified otherwise.

2.14 UNDERGROUND STRUCTURES

****

NOTE: Edit this paragraph to comply with project requirements concerning the type of structure or duct, strength of concrete, concrete mix, metal accessories, and excavating and grading. Indicate special reinforcing where required, particularly with duct banks of non-rectangular cross-section. Contact local telephone company, where applicable, concerning the size of all signal manholes and the number and type of signal duct required. Determine availability since aircraft or H20 highway loadings may not be available in precast.

For Navy projects only, see standard sketches UG-1 through UG-7, covering manholes and handholes located at http://www.wbdg.org/ccb/NAVGRAPH/graphtoc.pdf**.Include the required sketches on the project drawings.**

****

Provide precast concrete underground structures or standard type cast-in-place manhole types as indicated, conforming to ASTM C857 and ASTM C478M ASTM C478. Top, walls, and bottom must consist of reinforced concrete. Walls and bottom must be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers must fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and

arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, must be adequate to accommodate the cable.

2.14.1 Cast-In-Place Concrete Structures

****
NOTE: Edit bracketed items at designer's discretion and as required where aircraft loading is in project.
****

Concrete must conform to Section [03 30 00 CAST-IN-PLACE CONCRETE][03 30 00.00 10 CAST-IN-PLACE CONCRETE].[Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers.][Concrete block must conform to ASTM C139 and Section 04 20 00, MASONRY.][Concrete block is not allowed in areas subject to aircraft loading.]

2.14.2 Precast Concrete Structures, Risers and Tops

Precast concrete underground structures may be provided in lieu of cast-in-place subject to the requirements specified below. Precast units must be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes.

2.14.2.1 General

Precast concrete structures must have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures must have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction must be the same as for cast-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work must have a 28-day compressive strength of not less than 30 MPa 4000 psi. Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures must be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

2.14.2.2 Design for Precast Structures

ACI 318M. In the absence of detailed on-site soil information, design for the following soil parameters/site conditions:

a. Angle of Internal Friction (phi) = 0.523 rad 30 degrees

b. Unit Weight of Soil (Dry) = 1760 kg/m^3 110 pcf, (Saturated) = 2080 kg/m^3 130 pcf

c. Coefficient of Lateral Earth Pressure (Ka) = 0.33

d. Ground Water Level = 915 mm 3 feet below ground elevation

****

NOTE: Specify H20 highway loading for most locations. Revise as required if loading in excess of H20 highway loading is required.

Indicate structures subject to aircraft loading on the drawings. Also show structure design requirements on the drawings. Decks and covers subject to aircraft loadings must be designed for loadings per FAA AC-150/5320-6 except as follows:

a. Covers must be designed for 45 000 kg 100,000 lb wheel loads with 1.72 MPa 250 psi tire pressure.

b. For spans of less than 0.6 m 2 feet in the least direction, a uniform live load of 2.24 Mpa 325 psi must be used.

c. For spans of 0.6 m 2 feet or greater in the least direction, the design must be based on the number of wheels which will fit the span. Wheel loads of 34,000 kg 75,000 pounds each must be used.

****

e. Vertical design loads must include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads must consider all types and magnitudes of vehicular (automotive, industrial, or aircraft) traffic to be encountered. The minimum design vertical load must be for H20 highway loading per AASHTO HB-17.

f. Horizontal design loads must include full geostatic and hydrostatic pressures for the soil parameters, water table, and depth of installation to be encountered. Also, horizontal loads imposed by adjacent structure foundations, and horizontal load components of vertical design loads, including impact, must be considered, along with a pulling-in iron design load of 26,700 N 6000 pounds.

g. Each structural component must be designed for the load combination and positioning resulting in the maximum shear and moment for thatparticular component.

h. Design must also consider the live loads induced in the handling, installation, and backfilling of the manholes. Provide lifting devices to ensure structural integrity during handling and installation.

2.14.2.3 Construction

Structure top, bottom, and wall must be of a uniform thickness of not less than 150 mm 6 inches. Thin-walled knock-out panels for designed or future duct bank entrances are not permitted. Provide quantity, size, and location of duct bank entrance windows as directed, and cast completely open by the precaster. Size of windows must exceed the nominal duct bank envelope dimensions by at least 305 mm 12 inches vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows must be a minimum of 150 mm 6 inches from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through

window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. Provide drain sumps a minimum of 305 mm 12 inches in diameter and 100 mm 4 inches deep for precast structures.

2.14.2.4 Joints

Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to ASTM C990M ASTM C990. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

2.14.3 Manhole Frames and Covers

****
NOTE: CID A-A-60005 is used below as a requirement for manhole frames and covers. Although this document has been withdrawn by GSA, it is still used as a requirement because manufacturers still use it as a design guide.
****

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

2.14.4 Handhole Frames and Covers

Frames and covers of steel must be welded by qualified welders in accordance with standard commercial practice. Steel covers must be rolled-steel floor plate having an approved antislip surface. Hinges must be of [stainless steel with bronze hinge pin] [wrought steel], 125 by 125 mm 5 by 5 inches by approximately 4.75 mm 3/16 inch thick, without screw holes, and must be for full surface application by fillet welding. Hinges must have nonremovable pins and five knuckles. The surfaces of plates under hinges must be true after the removal of raised antislip surface, by grinding or other approved method.

[2.14.5 Frames and Covers for Airfield Facilities

****
NOTE: Use this paragraph for structures subject to aircraft loading.
****

Fabricate frames and covers for airfield use of standard commercial grade steel welded by qualified welders in accordance with AWS D1.1/D1.1M. Covers must be of rolled steel floor plate having an approved anti-slip surface. Steel frames and covers must be hot dipped galvanized after fabrication.

][2.14.6 Ductile Iron Frames and Covers for Airfield Facilities

****
NOTE: As an option, the designer may also allow the

use of this paragraph for structures subject to aircraft loading.

****

At the contractor's option, ductile iron covers and frames designed for a minimum proof load of 45,000 kg 100,000 pounds may be provided in lieu of the steel frames and covers indicated. Covers must be of the same material as the frames (i.e. ductile iron frame with ductile iron cover, galvanized steel frame with galvanized steel cover). Perform proof loading in accordance with CID A-A-60005 and ASTM A48/A48M. Proof loads must be physically stamped into the cover. Provide the Contracting Officer copies of previous proof load test results performed on the same frames and covers as proposed for this contract. Modify the top of the structure to accept the ductile iron structure in lieu of the steel structure indicated. The finished structure must be level and non-rocking, with the top flush with the surrounding pavement.

]2.14.7 Brick for Manhole Collar

Provide sewer and manhole brick conforming to ASTM C32, Grade MS.

2.14.8 Composite/Fiberglass Handholes and Covers

Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass conforming to ANSI/SCTE 77.

2.15 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

The metal portion of racks and arms must be zinc-coated after fabrication.

2.15.1 Cable Rack Stanchions

The wall bracket or stanchion must be 100 mm 4 inches by approximately 38 mm by 4.76 mm 1-1/2 inch by 3/16 inch channel steel, or 100 mm 4 inches by approximately 25 mm 1 inch glass-reinforced nylon with recessed bolt mounting holes, 1220 mm 48 inches long (minimum) in manholes. Slots for mounting cable rack arms must be spaced at 200 mm 8 inch intervals.

2.15.2 Rack Arms

Cable rack arms must be steel or malleable iron or glass reinforced nylon and must be of the removable type. Rack arm length must be a minimum of 200 mm 8 inches and a maximum of 305 mm 12 inches.

2.15.3 Insulators

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

2.16 CABLE TAGS IN MANHOLES

****

NOTE: Verify cable labeling requirements with the local Activity.

****

Provide tags for each power cable located in manholes. The tags must be polyethylene. Do not provide handwritten letters. The first position on the power cable tag must denote the voltage. The second through sixth

positions on the tag must identify the circuit. The next to last position must denote the phase of the circuit and include the Greek "phi" symbol. The last position must denote the cable size. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

2.16.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 22.4 MPa 3250 pounds per square inch; and that are 2 millimeter 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 77 degrees C 170 degrees F. Provide 1.3 mm 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties must have a minimum loop tensile strength of 778.75 N 175 pounds. The cable tags must have black block letters, numbers, and symbols 25 mm one inch high on a yellow background. Letters, numbers, and symbols must not fall off or change positions regardless of the cable tags' orientation.

2.17 MEDIUM VOLTAGE ABOVE GROUND CABLE TERMINATING CABINETS

****

NOTE: Cable terminating cabinets may be used for above ground applications only. They may be utilized in place of manholes for cable splicing where the local water table does not allow for manhole drainage, or in limited applications where it is desirable to provide a dead-break circuit sectionalizing point for circuit isolation. Loadbreak connectors are not available for applications above 200 A.

****

Cable terminating cabinets must be hook-stick operable, deadfront construction conforming to the requirements of IEEE C37.20.3, Category A. Provide cabinets with [200 A. loadbreak junctions and elbow-type separable loadbreak connectors, cable parking stands, and grounding lugs][600 A. dead-break junctions and elbow-type separable dead-break connectors, cable parking stands, and grounding lugs]. Provide cable terminating equipment in conformance with IEEE 386.

Ratings at 60 Hz must be:

Nominal voltage (kV)	[_____]
Rated maximum voltage (kV)	[[15][25][35]]
Rated continuous current (A)	[[200][600]]
One-second short-time current-carrying capacity (kA)	[_____]
BIL (kV)	[_____]

2.18 LOW VOLTAGE ABOVE GROUND TERMINATION PEDESTAL

Provide copolymer polypropylene, low voltage above ground termination pedestal manufactured through an injection molding process. Pedestals must resist fertilizers, salt air environments and ultra-violet radiation. Pedestal top must be imprinted with a "WARNING" and "ELECTRIC" identification. Pedestal must contain [three][four] lay-in six port connectors. Connectors must be NEMA C119.4, Class "A", dual rated for aluminum or copper, and capable of terminating conductors ranging from 10 AWG to 500 kcmil. Protect each connector with a clear, hard lexan (plastic) cover. Pedestal must be provided with rust-free material and stainless steel hardware. Pedestal must be lockable.

2.19 PROTECTIVE DEVICES AND COORDINATION

****

NOTE: Do not use on Navy Projects. Per UFC 3-501-01, "Electrical Engineering", the designer of record is responsible for providing a design stage and a final coordination study based on as built conditions.

For the Army and Air Force, the designer is responsible for specifying the requirement for fuses, circuit breakers, protective relays, or other protective devices associated with the project and depicting them on the drawings. Select and specify the protective devices to protect electrical power system conductors or equipment against sustained overloads, in-rush conditions, electrical faults, or other abnormal power system or equipment operating conditions, in accordance with IEEE 242, and IEEE 141. Utilize section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION and coordinate the incorporation of the protective device requirements identified in the other equipment specification sections.

****

Provide protective devices and coordination as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

2.20 SOURCE QUALITY CONTROL

2.20.1 Arc-Proofing Test for Cable Fireproofing Tape

Manufacturer must test one sample assembly consisting of a straight lead tube 305 mm 12 inches long with a 65.5 mm 2 1/2 inch outside diameter, and a 3.175 mm 1/8 inch thick wall, and covered with one-half lap layer of arc and fireproofing tape per manufacturer's instructions. The arc and fireproofing tape must withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of 13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode must be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. The arc must be directed toward the sample assembly accurately positioned 5

(plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Each sample assembly must be tested at three unrelated points. Start time for tests must be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time must be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube. Submittals for arc-proofing tape must indicate that the test has been performed and passed by the manufacturer.

2.20.2 Medium Voltage Cable Qualification and Production Tests

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

PART 3 EXECUTION

3.1 INSTALLATION

****
NOTE: Soil treatment for termite control must conform to Section 31 31 16 SOIL TREATMENT FOR SUBTERRANEAN TERMITE CONTROL, except that application to direct burial cable installation must be as specified. In lieu of soil poisoning, cable in direct-buried EPC-40-PVC conduit can be a more economical and practical way of protecting cable from termites.
****

****
NOTE: CALPUC publication applies only to State of California Public Utilities Commission CALPUC G.O.128, "Construction of Underground Electric Supply and Communication System" for underground electrical work. For other states, delete this publication and insert other publications which govern underground electrical work for that state. Revise reference paragraph to include deletion or addition of state publication.
****

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70 and IEEE C2[and CALPUC G.O.128] as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758 and RUS Bull 1751F-644.

3.2 CABLE INSPECTION

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

[3.3 CABLE INSTALLATION PLAN AND PROCEDURE

****
NOTE: Use this paragraph when pulling cable between

manholes. Do not use this paragraph when only installing between poles and manholes

Choose checklist for small electrical distribution jobs, and calculations for large jobs.

****

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

[Calculations and pulling plan must include:

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

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

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

e. Cable pulling tension calculations of all cable pulls.

f. Cable percentage conduit fill.

g. Cable sidewall bearing pressure.

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

i. Cable jam ratio.

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

k. Maximum allowable pulling tension on pulling device.

]]3.4 UNDERGROUND FEEDERS SUPPLYING BUILDINGS

****

NOTE: For Navy only, choose PVC.

****

Terminate underground feeders supplying building at a point 1525 mm 5 feet outside the building and projections thereof, except that conductors must be continuous to the terminating point indicated. Coordinate connections of the feeders to the service entrance equipment with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide [PVC, Type EPC-40][IMC][RGS] conduit from the supply equipment to a point 1525 mm 5 feet outside the building and projections thereof. Protect ends of underground conduit with plastic

plugs until connections are made.

[Encase the underground portion of the conduit in a concrete envelope and bury as specified for underground duct with concrete encasement.

]3.5 UNDERGROUND STRUCTURE CONSTRUCTION

****
NOTE: Edit this paragraph to comply with project requirements concerning the type of structure, strength of concrete, concrete mix, metal accessories, and excavating and grading. Indicate special reinforcing where required. Contact local telephone company, where applicable, concerning the size of all signal manholes and the number and type of signal duct required. Determine availability since H20 or aircraft loadings may not be available in precast.

For Navy projects, see standard sketches UG-1 through UG-7 covering manholes and handholes. Include the required sketches on the project drawings.
****

Provide standard type cast-in-place construction as specified herein and as indicated, or precast construction as specified herein. Horizontal concrete surfaces of floors must have a smooth trowel finish. Cure concrete by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound must conform to ASTM C309. Locate duct entrances and windows in the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground structures must fit the frames without undue play. Steel and iron must be formed to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Manhole locations, as indicated, are approximate. Coordinate exact manhole locations with other utilities and finished grading and paving.

3.5.1 Cast-In-Place Concrete Structures

[Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers.][Provide concrete block conforming to ASTM C139 and Section 04 20 00 MASONRY.][Concrete block is not allowed in areas subject to aircraft loading.]

3.5.2 Precast Concrete Construction

Set commercial precast structures on 150 mm 6 inches of level, 90 percent compacted granular fill, 19 mm to 25 mm 3/4 inch to 1 inch size, extending 305 mm 12 inches beyond the structure on each side. Compact granular fill by a minimum of four passes with a plate type vibrator. Installation must additionally conform to the manufacturer's instructions.

3.5.3 Pulling-In Irons

Provide steel bars bent as indicated, and cast in the walls and floors. Alternatively, pipe sleeves may be precast into the walls and floors where required to accept U-bolts or other types of pulling-in devices possessing the strengths and clearances stated herein. The final installation of pulling-in devices must be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor the irons must be a minimum of 150 mm 6 inches from the edge of the sump, and in the walls the irons must be located within 150 mm 6 inches of the projected center of the duct bank pattern or precast window in the opposite wall. However, the pulling-in iron must not be located within 150 mm 6 inches of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 150 mm 6 inch clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 915 mm 3 foot length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner must be positioned directly in line with, or when not possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of 75 mm 3 inches from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons must have a clear projection into the structure of approximately 100 mm 4 inches and must be designed to withstand a minimum pulling-in load of 26,700 N 6000 pounds. Irons must be hot-dipped galvanized after fabrication.

3.5.4 Cable Racks, Arms and Insulators

Cable racks, arms and insulators must be sufficient to accommodate the cables. Space racks in power manholes not more than 915 mm 3 feet apart, and provide each manhole wall with a minimum of two racks. Space racks in signal manholes not more than 420 mm 16 1/2 inches apart with the end rack being no further than 305 mm 12 inches from the adjacent wall. Methods of anchoring cable racks must be as follows:

a. Provide a 15 mm diameter by 125 mm 5/8 inch diameter by 5 inch long anchor bolt with 75 mm 3 inch foot cast in structure wall with 50 mm 2 inch protrusion of threaded portion of bolt into structure. Provide 15 mm 5/8 inch steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.

b. Provide concrete channel insert with a minimum load rating of 1192 kg per meter 800 pounds per foot. Insert channel must be steel of the same length as "vertical rack channel;" channel insert must be cast flush in structure wall. Provide 15 mm 5/8 inch steel nuts in channel insert to receive 15 mm diameter by 75 mm 5/8 inch diameter by 3 inch long steel, square head anchor bolts.

c. Provide concrete "spot insert" at each anchor bolt location, cast flush in structure wall. Each insert must have minimum 365 kg 800 pound load rating. Provide 15 mm diameter by 75 mm 5/8 inch diameter by 3 inch long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing

bolts.

3.5.5 Field Painting

****
NOTE: Edit to match products contained in Part 2. Choose cast-iron for most applications. Ductile iron or steel may be required for areas subject to heavy loading such as airfields or industrial areas.
****

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

[3.6 DIRECT BURIAL CABLE SYSTEM

****
NOTE: Refer to UFC 3-550-01, "Exterior Electrical Power Distribution", for guidance on when direct buried wiring may be permitted.
****

Cables must be buried directly in the earth below the frostline [as indicated][to the requirements of NFPA 70 and IEEE C2, whichever is more stringent].

3.6.1 Trenching

Excavate trenches for direct-burial cables to provide a minimum cable cover of 610 mm 24 inches below finished grade for power conductors operated at 600 volts or less, and 765 mm 30 inches below finished grade for over 600 volts in accordance with IEEE C2. When rock is encountered, remove to a depth of at least 75 mm 3 inches below the cable and fill the space with sand or clean earth free from particles larger than 6 mm 1/4 inch. Bottoms of trenches must be smooth and free of stones and sharp objects. Where materials in bottoms of trenches are other than sand, a 75 mm 3 inch layer of sand must be laid first and compacted to approximate densities of surrounding firm soil. Trenches must be not less than [150][200] mm [6][8] inches wide, and must be in straight lines between cable markers.[Cable plows must not be used.] Bends in trenches must have a radius [of not less than 915 mm 36 inches][consistent with the cable manufacturer's published minimum cable bending radius for the cable installed].

3.6.2 Cable Installation

****
NOTE: Where soil is known to be rocky, provide selected backfill for cable protection. Specify bend radius in accordance with NFPA 70.
****

Unreel cables along the sides of or in trenches and carefully place on sand or earth bottoms. Pulling cables into direct-burial trenches from a fixed reel position is not permitted, except as required to pull cables through conduits under paving or railroad tracks.

Where two or more cables are laid parallel in the same trench, space cables laterally at not less than 75 mm 3 inches apart, except that communication

cable must be separated from power cable by a minimum distance of 305 mm 12 inches.

Where direct-burial cables cross under roads or other paving exceeding 1.5 m 5 feet in width, such cables must be installed in[concrete-encased] ducts. Where direct-burial cables cross under railroad tracks, such cables must be installed in [reinforced concrete-encased ducts][ducts installed through rigid galvanized steel sleeves]. Ducts must extend at least 1.5 m 5 feet beyond each edge of any paving and at least 1.5 m 5 feet beyond each side of any railroad tracks. Cables may be pulled into duct from a fixed reel where suitable rollers are provided in the trench. Where direct burial cable transitions to duct-enclosed cable, direct-burial cables must be centered in duct entrances, and a waterproof nonhardening mastic compound must be used to facilitate such centering. If paving or railroad tracks are in place where cables are to be installed, coated rigid steel conduits driven under the paving or railroad tracks may be used in lieu of concrete-encased ducts. Prevent damage to conduit coatings by providing ferrous pipe jackets or by predrilling. Where cuts are made in any paving, the paving and subbase must be restored to their original condition. Where cable is placed in duct(e.g. under paved areas, roads, or railroads), slope ducts to drain.

3.6.3 Splicing

****

NOTE: Direct earth burial cables generally require direct burial splices. Observe marker slab requirements previously covered in this specification. Direct burial splices are allowable for NAVFAC projects only, do not specify for Army and Air Force Projects. For Army and Air Force projects, use the second bracketed option.

****

Provide cables in one piece without splices between connections except where the distance exceeds the lengths in which cables are manufactured.[Where splices are required, provide splices designed and rated for direct burial.][Where splices are required, install splices only in maintenance manholes/handholes or cabinets/pedestals.]

3.6.4 Bends

Bends in cables must have an inner radius not less than those specified in NFPA 70 for the type of cable, or manufacturer's recommendation.

3.6.5 Horizontal Slack

Leave approximately 915 mm 3 feet of horizontal slack in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought above ground. Where cable is brought above ground, leave additional slack to make necessary connections.[Enclose splices in lead-sheathed or armored cables in split-type cast-iron splice boxes; after completion of the connection, fill with insulating filler compound and tightly clamp the box.]

3.6.6 Identification Slabs[or Markers]

Provide a slab at each change of direction of cable, over the ends of ducts or conduits which are installed under paved areas and roadways[, over the

ends of ducts or conduits stubbed out for future use][, and over each splice]. Identification slabs must be of concrete, approximately 500 mm square by 150 mm 20 inches square by 6 inches thick and must be set flat in the ground so that top surface projects not less than 20 mm 3/4 inch, nor more than 30 mm 1 1/4 inchesabove ground. Concrete must have a compressive strength of not less than 20 MPa 3000 psi and have a smooth troweled finish on exposed surface. Inscribe an identifying legend such as "electric cable," "telephone cable," "splice," or other applicable designation on the top surface of the slab before concrete hardens. Inscribe circuit identification symbols on slabs as indicated. Letters or figures must be approximately 50 mm 2 inches high and grooves must be approximately 6 mm 1/4 inch in width and depth. Install slabs so that the side nearest the inscription on top must include an arrow indicating the side nearest the cable. Provide color, type and depth of warning tape as specified in Section [31 23 00.00 20 EXCAVATION AND FILL][31 00 00 EARTHWORK].

]3.7 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.7.1 Requirements

****
NOTE: Indicate direct buried conduit and concrete encased conduit on drawings. Ensure that duct is specified to be installed below the frost line depth.
****

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Ducts must have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of [75 mm][100 mm] per 30 m [3][4] inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius must be 450 mm 18 inches for ducts of less than 80 mm 3 inch diameter, and 900 mm 36 inches for ducts 80 mm 3 inches or greater in diameter. Otherwise, long sweep bends having a minimum radius of 7.6 m 25 feet must be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used must be 30 degrees and manufactured bends must be used. Provide ducts with end bells whenever duct lines terminate in structures.

3.7.2 Treatment

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

3.7.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 75 mm 3 inches and

larger, draw a flexible testing mandrel approximately 305 mm 12 inches long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than 75 mm 3 inches, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.7.4 Jacking and Drilling Under Roads and Structures

Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, must be zinc-coated, rigid steel, jacked into place. Where ducts are jacked under existing pavement, rigid steel conduit must be installed because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 15 m 50 feet in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks must be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 1.2 m 4 feet on centers. [Hydraulic jet method must not be used.]

[3.7.5 Galvanized Conduit Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) in wet locations must be PVC coated and must extend from at least 50 mm 2 inches within the concrete to the first coupling or fitting outside the concrete (minimum of 150 mm 6 inches from penetration).

]3.7.6 Multiple Conduits

Separate multiple conduits by a minimum distance of 75 mm 3 inches[, except that light and power conduits must be separated from control, signal, and telephone conduits by a minimum distance of [300] mm [12] inches]. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly must consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 3050 mm 10 feet of conduit assembly.

3.7.7 Conduit Plugs and Pull Rope

New conduit indicated as being unused or empty must be provided with plugs on each end. Plugs must contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 915 mm 3 feet of slack at each end of unused or empty conduits.

3.7.8 Conduit and Duct Without Concrete Encasement

Depths to top of the conduit must be not less than 610 mm 24 inches below finished grade. Provide not less than 75 mm 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 75 mm 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 6.25 mm 1/4 inch sieve. The first 150 mm 6 inch layer of backfill cover must be sand compacted as previously specified. The rest of the excavation

must be backfilled and compacted in 75 to 150 mm 3 to 6 inch layers. Provide color, type and depth of warning tape as specified in Section [31 23 00.00 20 EXCAVATION AND FILL][31 00 00 EARTHWORK].

3.7.8.1 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 75 mm 3 inch concrete cover around ducts. Concrete encasement must extend at least 1525 mm 5 feet beyond the edges of paved areas and roads, and 3660 mm 12 feet beyond the rails on each side of railroad tracks. Depths to top of the concrete envelope must be not less than 610 mm 24 inches below finished grade[, and under railroad tracks not less than 1270 mm 50 inches below the top of the rails].

[3.7.8.2 Directional Boring

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

[For distribution voltages greater than 1000 volts and less than 34,500 volts, depths to the top of the conduit must not be less than 1220 mm 48 inches in pavement-covered areas and not less than 3050 mm 120 inches in non-pavement-covered areas.][For distribution voltages less than 1000 volts, depths to the top of the conduit must not be less than 1220 mm 48 inches in pavement- or non-pavement-covered areas.][For branch circuit wiring less than 600 volts, depths to the top of the conduit must not be less than 610 mm 24 inches in pavement- or non-pavement-covered areas.]

]3.7.9 Duct Encased in Concrete

****

NOTE: Edit this paragraph to comply with project requirements concerning type of structure or duct, strength of concrete, concrete mix, metal accessories, and excavating and grading. Indicate special reinforcing where required, particularly with duct banks of non-rectangular cross-section, and for ductbanks under road crossings, railroad crossings and airfield paving crossings. Reinforcing should extend at least 1.5 m 5 feet beyond the edge of pavement or railroad tracks.

Medium voltage cables and campus distribution cables of telecommunications backbone distribution system must be in duct encased in concrete, unless otherwise required by local Activity. Contact local telephone company, where applicable, concerning size of signal manholes and number and type of signal duct required.

****

****

NOTE: Provide steel reinforcing per the following table:

COVER	UNREINFORCED	REINFORCED*
≥450 mm 18 in and <1220 mm 48 in	Undeveloped areas.	Transition from good to poor soil conditions where differential settlement is anticipated.
≥610 mm 24 in and <1220 mm 48 in	Roads/paved areas for light to moderate traffic loads.	Other roads/paved areas (i.e. supporting trucks, cranes, ultra-heavy loads, etc.
≥1220 mm 48 in	All ductbanks (except as noted).	Under railroad tracks. Transition from good to poor soil conditions where differential settlement is anticipated.

*** Use minimum reinforcement of 4 #13 #4 w/ #10 #3 ties at 915 mm 3 feet o/c for ductbanks 760 mm 30 inches or less wide.**
*** Use minimum reinforcement of 6 #13 #4 w/ #10 #3 ties at 915 mm 3 feet o/c for ductbanks greater than 760 mm 30 inches wide.**
*** Consult with structural or geotechnical engineer for assistance.**

****

Construct underground duct lines of individual conduits encased in concrete. Depths to top of the concrete envelope must be not less than 450 mm 18 inches below finished grade[, except under roads and pavement, concrete envelope must be not less than 610 mm 24 inches below finished grade][, and under railroad tracks not less than 1270 mm 50 inches below the top of the rails]. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank must be rectangular in cross-section and must provide at least 75 mm 3 inches of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 75 mm 3 inches. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring must be done by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly.[Provide steel reinforcing in the concrete envelope as indicated.][Provide color, type and depth of warning tape as specified in Section [31 00 00 EARTHWORK][31 23 00.00 20 EXCAVATION AND FILL.]]

3.7.9.1 Connections to Manholes

Duct bank envelopes connecting to underground structures must be flared to have enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section must be larger than the corresponding manhole opening dimensions by no less than 300 mm 12 inches in each direction. Perimeter of the duct bank opening in the underground structure must be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal between the envelope and the wall of the structure.

3.7.9.2 Connections to Existing Underground Structures

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

3.7.9.3 Connections to Existing Concrete Pads

****

NOTE: Choose second bracketed option where existing concrete is reinforced.

****

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

3.7.9.4 Connections to Existing Ducts

Where connections to existing duct banks are indicated, excavate the banks to the maximum depth necessary. Cut off the banks and remove loose concrete from the conduits before new concrete-encased ducts are installed. Provide a reinforced concrete collar, poured monolithically with the new duct bank, to take the shear at the joint of the duct banks.[Remove existing cables which constitute interference with the work.][Abandon in place those no longer used ducts and cables which do not interfere with the work.]

3.7.9.5 Partially Completed Duct Banks

During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud, and, and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 610 mm 2 feet back into the envelope and a minimum of 610 mm 2 feet beyond the end of the envelope. Provide one No. 4 bar in each corner, 75 mm 3 inches from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 305 mm one footapart. Restrain reinforcing assembly from moving during concrete pouring.

[3.7.9.6 Removal of Ducts

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

]3.8 CABLE PULLING

****
NOTE: For Navy projects, choose bracketed item for tape shielding and coordinate with Part 2 PRODUCTS.
****

[Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables.]Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with[tape][or][wire] shield must have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.8.1 Cable Lubricants

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

3.9 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure.

3.9.1 Cable Tag Installation

****
NOTE: On contracts where existing cables are recircuited special attention should be given to changing existing cable identification tags in each manhole to reflect new circuit numbers.
****

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

3.10 CONDUCTORS INSTALLED IN PARALLEL

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

3.11 LOW VOLTAGE CABLE SPLICING AND TERMINATING

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

[3.11.1 Terminating Aluminum Conductors

a. Use particular care in making up joints and terminations. Remove surface oxides by cleaning with a wire brush or emery cloth. Apply joint compound to conductors, and use UL-listed solid aluminum connectors for connecting aluminum conductors. When connecting aluminum to copper conductors, use connectors specifically designed for this purpose.

b. Terminate aluminum conductors to copper bus either by: (1) in line splicing a copper pigtail to the aluminum conductor (copper pigtail must have a ampacity at least that of the aluminum conductor); or (2) using a circumferential compression type, aluminum bodied terminal lug UL listed for AL/CU and steel Belleville spring washers, flat washers, bolts, and nuts. Belleville spring washers must be cadmium-plated hardened steel. Install the Belleville spring washers with the crown up toward the nut or bolt head, with the concave side of the Belleville bearing on a heavy-duty, wide series flat washer of larger diameter than the Belleville. Tighten nuts sufficient to flatten Belleville and leave in that position. Lubricate hardware with joint compound prior to making connection. Wire brush and apply joint compound to conductor prior to inserting in lug.

c. Terminate aluminum conductors to aluminum bus by using all-aluminum nuts, bolts, washers, and lugs. Wire brush and apply inhibiting compound to conductor prior to inserting in lug. Lubricate hardware with joint compound prior to making connection; if bus contact surface is unplated, scratch-brush and coat with joint compound (without grit).

]3.12 MEDIUM VOLTAGE CABLE TERMINATIONS

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

3.13 MEDIUM VOLTAGE CABLE JOINTS

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

3.13.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original

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

[3.13.2 Joints in Armored Cables

Armored cable joints must be enclosed in compound-filled, cast-iron or alloy splice boxes equipped with stuffing boxes and armor clamps of a suitable type and size for the cable being installed.

]3.14 CABLE END CAPS

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

[3.15 LIVE END CAPS

****
NOTE: Live end caps are only required when cable is required to remain unterminated, but energized. Live end cap locations must be indicated on the drawings.
****

Provide live end caps for single conductor medium voltage cables where indicated.

]3.16 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in underground structures.

3.16.1 Fireproofing Tape

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

[3.16.2 Tape-Wrap

Tape-wrap metallic-sheathed or metallic armored cables without a nonmetallic protective covering over the sheath or armor prior to application of fireproofing. Wrap must be in the form of two tightly applied half-lapped layers of a pressure-sensitive 0.254 mm 10 mil thick plastic tape, and must extend not less than 25 mm one inch into the duct. Even out irregularities of the cable, such as at splices, with insulation putty before applying tape.

]3.17 GROUNDING SYSTEMS

****

NOTE: Determine the grounding requirements for each project. Show all necessary ground rods and ground girdles on the drawings.

****

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding [25][_____] ohms.

3.17.1 Grounding Electrodes

****

NOTE: Investigate the soil resistivity during the preliminary design phase to determine the design required to ensure that the grounding values are obtained. For areas where the water table is low and/or the soil resistivity is high (such as volcanic soils, sand, or rock), delete the additional electrode provisions and provide a design to meet the site requirements.

****

Provide cone pointed driven ground rods driven full depth plus[150 mm 6 inches][300 mm 12 inches], installed to provide an earth ground of the appropriate value for the particular equipment being grounded.
If the specified ground resistance is not met, an additional ground rod must be provided in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

3.17.2 Grounding Connections

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

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

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

3.17.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.[Provide direct connections to the grounding conductor with 600 v insulated, full-size conductor for each grounded neutral of each feeder circuit, which is spliced within the manhole.]

3.17.4 Ground Cable Crossing Expansion Joints

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

3.17.5 Manhole Grounding

****
NOTE: Use bracketed sentence when 4-wire circuit including grounded neutral is provided.
****

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately 305 mm 12 inches above finished floor. Secure the conductor to the manhole walls at intervals not exceeding 914 mm 36 inches. Connect the conductor to the manhole grounding electrode with 4/0 AWG conductor. Connect all incoming 4/0 grounding conductors to the ground loop adjacent to the point of entry into the manhole. Bond the ground loop to all cable shields, metal cable racks, and other metal equipment with a minimum 6 AWG conductor.

[3.17.6 Fence Grounding

****
NOTE: Use this paragraph only when fence is required to be grounded in accordance with IEEE C2, NFPA 70, or other requirements.
****

[Provide grounding for fences as indicated.][Provide grounding for fences with a ground rod at each fixed gate post and at each corner post.] Drive ground rods until the top is 305 mm 12 inches below grade. Attach a No. 4 AWG copper conductor, by exothermic weld to the ground rods and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 305 mm 12 inches of fence mesh and fasten by two approved bronze compression fittings, one to bond wire to post and the other to bond wire to fence. Each gate section must be bonded to its gatepost by a 3 by 25 mm 1/8 by one inch flexible braided copper strap and ground post clamps. Clamps must be of the anti-electrolysis type.

][3.17.7 Metal Splice Case Grounding

Metal splice cases for medium-voltage direct-burial cable must be grounded by connection to a driven ground rod located within 600 mm 2 feet of each splice box using a grounding electrode conductor having a current-carrying capacity of at least 20 percent of the individual phase conductors in the associated splice box, but not less than No. 6 AWG.

]3.18 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section [31 23 00.00 20 EXCAVATION AND FILL][31 00 00 EARTHWORK].

3.18.1 Reconditioning of Surfaces

3.18.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct [or direct burial cable]. Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.[Provide work in accordance with Section 32 92 19 SEEDING and Section 32 93 00 EXTERIOR PLANTS.]

3.18.1.2 Paving Repairs

****
NOTE: Where paving repairs are a very minor part of project, the first bracketed paragraph may be used; otherwise, use the second bracketed paragraph and include other sections as needed (also include necessary cutting and patching details on the drawings.)
****

****
NOTE: Insert appropriate Section number and title in the blank below.
****

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists [, restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.][Make repairs as specified in Section [32 13 13.06 PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES][_____].]

3.19 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section [03 30 00 CAST-IN-PLACE CONCRETE][03 30 00.00 10 CAST-IN-PLACE CONCRETE for Army projects].

3.19.1 Concrete Slabs for Equipment

Unless otherwise indicated, the slab must be at least 200 mm 8 inches thick, reinforced with a 152 mm by 152 mm - MW19 by MW19 (6 by 6 - W2.9 by W2.9) 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 100 mm 4 inches from the top of the slab. Slab must be placed on a 150 mm 6 inch thick, well-compacted gravel base. Top of concrete slab must be approximately 100 mm 4 inches above finished grade with gradual slope for drainage. Edges above grade must have 15 mm 1/2 inch chamfer. Slab must be of adequate size to project at least 200 mm 8 inches beyond the equipment.

Stub up conduits, with bushings, 50 mm 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

[3.19.2 Sealing

****
NOTE: Require sealing of holes (windows) in the concrete pad if rodent intrusion is a problem.
****

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

]3.20 FIELD QUALITY CONTROL

3.20.1 Performance of Field Acceptance Checks and Tests

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

3.20.1.1 Medium Voltage Cables

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

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

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

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

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

(5) Inspect for proper fireproofing.

(6) Visually inspect jacket and insulation condition.

(7) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform a shield continuity test on each power cable by ohmmeter method. Record ohmic value, resistance values in excess of 10 ohms per 1000 feet of cable must be investigated and justified.

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

CABLE RATING AC TEST VOLTAGE for ACCEPTANCE TESTING	
5 kV	10kV rms(peak)
8 kV	13kV rms(peak)
15 kV	20kV rms(peak)
25 kV	31kV rms(peak)
35 kV	44kV rms(peak)

CABLE RATING AC TEST VOLTAGE for MAINTENANCE TESTING	
5 kV	7kV rms(peak)
8 kV	10kV rms(peak)
15 kV	16kV rms(peak)
25 kV	23kV rms(peak)
35 kV	33kV rms(peak)

3.20.1.2 Low Voltage Cables, 600-Volt

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

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

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

(3) Verify tightness of accessible bolted electrical connections.

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

(5) Visually inspect jacket and insulation condition.

(6) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 1000 volts dc for one minute.

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

3.20.1.3 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and specifications

b. Electrical tests

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

3.20.2 Follow-Up Verification

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

-- End of Section --