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USACE / NAVFAC / AFCEC UFGS-33 71 02 (August 2021)

Preparing Activity: NAVFAC

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Superseding  
UFGS-33 71 02 (February 2015)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2025

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### SECTION TABLE OF CONTENTS

#### DIVISION 33 - UTILITIES

#### SECTION 33 71 02

#### UNDERGROUND ELECTRICAL DISTRIBUTION

08/21

#### PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SYSTEM DESCRIPTION
- 1.3 RELATED REQUIREMENTS
- 1.4 DEFINITIONS
- 1.5 SUBMITTALS
- 1.6 QUALITY ASSURANCE
  - 1.6.1 Precast Underground Structures
  - 1.6.2 Certificate of Competency for Cable Splicer/Terminator
  - 1.6.3 Cable Installer Qualifications
  - 1.6.4 Directional Boring Certificate of Conformance
  - 1.6.5 Regulatory Requirements
  - 1.6.6 Standard Products
    - 1.6.6.1 Alternative Qualifications
    - 1.6.6.2 Material and Equipment Manufacturing Date

#### PART 2 PRODUCTS

- 2.1 CONDUIT, DUCTS, AND FITTINGS
  - 2.1.1 Rigid Metal Conduit
    - 2.1.1.1 Rigid Metallic Conduit, PVC Coated
  - 2.1.2 Intermediate Metal Conduit
  - 2.1.3 Plastic Conduit for Direct Burial and Riser Applications
  - 2.1.4 Plastic Duct for Concrete Encasement
  - 2.1.5 High Density Polyethylene (HDPE) Electrical Conduit for Directional Boring
  - 2.1.6 Duct Sealant
  - 2.1.7 Fittings
    - 2.1.7.1 Metal Fittings
    - 2.1.7.2 PVC Conduit Fittings
    - 2.1.7.3 PVC Duct Fittings
    - 2.1.7.4 Outlet Boxes for Steel Conduit
- 2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

- 2.2.1 Conductor Types
- 2.2.2 Conductor Material
- 2.2.3 Jackets
- 2.2.4 In Duct
- 2.2.5 Cable Marking
- 2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS
- 2.4 LOW VOLTAGE SPLICES
  - 2.4.1 Heat Shrinkable Splice
  - 2.4.2 Cold Shrink Rubber Splice
- 2.5 MEDIUM VOLTAGE CABLE
  - 2.5.1 Cable Configuration
  - 2.5.2 Conductor Material
  - 2.5.3 Insulation
  - 2.5.4 Shielding
  - 2.5.5 Neutrals
  - 2.5.6 Jackets
- 2.6 MEDIUM VOLTAGE CABLE TERMINATIONS
  - 2.6.1 Cold-Shrink Type
  - 2.6.2 Heat Shrinkable Type
  - 2.6.3 Separable Insulated Connector Type
- 2.7 MEDIUM VOLTAGE CABLE JOINTS
  - 2.7.1 Heat-Shrinkable Joint
  - 2.7.2 Cold-Shrink Rubber-Type Joint
- 2.8 TELECOMMUNICATIONS CABLING
- 2.9 LIVE END CAPS
- 2.10 TAPE
  - 2.10.1 Insulating Tape
  - 2.10.2 Buried Warning and Identification Tape
  - 2.10.3 Fireproofing Tape
- 2.11 PULL ROPE
- 2.12 GROUNDING AND BONDING
  - 2.12.1 Driven Ground Rods
  - 2.12.2 Grounding Conductors
- 2.13 CAST-IN-PLACE CONCRETE
- 2.14 UNDERGROUND STRUCTURES
  - 2.14.1 Cast-In-Place Concrete Structures
  - 2.14.2 Precast Concrete Structures, Risers and Tops
    - 2.14.2.1 General
    - 2.14.2.2 Design for Precast Structures
    - 2.14.2.3 Construction
    - 2.14.2.4 Joints
  - 2.14.3 Manhole Frames and Covers
  - 2.14.4 Handhole Frames and Covers
  - 2.14.5 Manhole Ladder
  - 2.14.6 Frames and Covers for Airfield Facilities
  - 2.14.7 Ductile Iron Frames and Covers for Airfield Facilities
  - 2.14.8 Brick for Manhole Collar
  - 2.14.9 Composite/Fiberglass Handholes and Covers
- 2.15 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)
  - 2.15.1 Cable Rack Stanchions
  - 2.15.2 Rack Arms
  - 2.15.3 Insulators
- 2.16 CABLE TAGS IN MANHOLES
  - 2.16.1 Polyethylene Cable Tags
- 2.17 MEDIUM VOLTAGE ABOVE GROUND CABLE TERMINATING CABINETS
- 2.18 LOW VOLTAGE ABOVE GROUND TERMINATION PEDESTAL
- 2.19 PROTECTIVE DEVICES AND COORDINATION
- 2.20 SOURCE QUALITY CONTROL
  - 2.20.1 Arc-Proofing Test for Cable Fireproofing Tape

2.20.2 Medium Voltage Cable Qualification and Production Tests

PART 3 EXECUTION

- 3.1 INSTALLATION
- 3.2 CABLE INSPECTION
- 3.3 CABLE INSTALLATION PLAN AND PROCEDURE
- 3.4 UNDERGROUND FEEDERS SUPPLYING BUILDINGS
- 3.5 UNDERGROUND STRUCTURE CONSTRUCTION
  - 3.5.1 Cast-In-Place Concrete Structures
  - 3.5.2 Precast Concrete Construction
  - 3.5.3 Pulling-In Irons
  - 3.5.4 Cable Racks, Arms and Insulators
  - 3.5.5 Field Painting
- 3.6 UNDERGROUND CONDUIT AND DUCT SYSTEMS
  - 3.6.1 Requirements
  - 3.6.2 Treatment
  - 3.6.3 Conduit Cleaning
  - 3.6.4 Jacking and Drilling Under Roads and Structures
  - 3.6.5 Galvanized Conduit Concrete Penetrations
  - 3.6.6 Multiple Conduits
  - 3.6.7 Conduit Plugs and Pull Rope
  - 3.6.8 Conduit and Duct Without Concrete Encasement
    - 3.6.8.1 Encasement Under Roads and Structures
    - 3.6.8.2 Directional Boring
  - 3.6.9 Duct Encased in Concrete
    - 3.6.9.1 Connections to Manholes
    - 3.6.9.2 Connections to Existing Underground Structures
    - 3.6.9.3 Connections to Existing Concrete Pads
    - 3.6.9.4 Connections to Existing Ducts
    - 3.6.9.5 Partially Completed Duct Banks
    - 3.6.9.6 Removal of Ducts
  - 3.6.10 Duct Sealing
- 3.7 CABLE PULLING
  - 3.7.1 Cable Lubricants
- 3.8 CABLES IN UNDERGROUND STRUCTURES
  - 3.8.1 Cable Tag Installation
- 3.9 CONDUCTORS INSTALLED IN PARALLEL
- 3.10 LOW VOLTAGE CABLE SPLICING AND TERMINATING
- 3.11 MEDIUM VOLTAGE CABLE TERMINATIONS
- 3.12 MEDIUM VOLTAGE CABLE JOINTS
  - 3.12.1 Joints in Shielded Cables
- 3.13 CABLE END CAPS
- 3.14 LIVE END CAPS
- 3.15 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES
  - 3.15.1 Fireproofing Tape
  - 3.15.2 Tape-Wrap
- 3.16 GROUNDING SYSTEMS
  - 3.16.1 Grounding Electrodes
  - 3.16.2 Grounding Connections
  - 3.16.3 Grounding Conductors
  - 3.16.4 Ground Cable Crossing Expansion Joints
  - 3.16.5 Manhole Grounding
  - 3.16.6 Fence Grounding
  - 3.16.7 Metal Splice Case Grounding
- 3.17 EXCAVATING, BACKFILLING, AND COMPACTING
  - 3.17.1 Reconditioning of Surfaces
    - 3.17.1.1 Unpaved Surfaces
    - 3.17.1.2 Paving Repairs

- 3.18 CAST-IN-PLACE CONCRETE
  - 3.18.1 Concrete Slabs (Pads) for Equipment
  - 3.18.2 Sealing
- 3.19 FIELD QUALITY CONTROL
  - 3.19.1 Performance of Field Acceptance Checks and Tests
    - 3.19.1.1 Medium Voltage Cables
    - 3.19.1.2 Low Voltage Cables, 600-Volt
    - 3.19.1.3 Grounding System
  - 3.19.2 Follow-Up Verification

-- End of Section Table of Contents --

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SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION  
08/21

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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).

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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 minimally acceptable  
material, usual methods and some of the most used  
alternatives. Different materials and methods,  
properly specified, indicated, and economically used  
will be acceptable when approved by the Contracting  
Officer.

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

NOTE: To download UFGS Forms, Graphics, and Tables,  
go to:  
<https://www.wbdg.org/dod/ufgs/ufgs-forms-graphics-tables>

#### 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.

<u>SKETCH NUMBER</u>	<u>TITLE</u>
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)

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NOTE: Ensure the following information is 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 rings.

5. Locations of faulted circuit indicators, when used.

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

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PART 1 GENERAL

1.1 REFERENCES

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

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

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

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

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 (ACI)

ACI 318M (2019; Errata 2022) Building Code Requirements for Structural Concrete & Commentary

ACI MNL-66 (2020) ACI Detailing Manual

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2025) Structural Welding Code - Steel

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8 (2013) Specification for Extruded  
Dielectric Shielded Power Cables Rated 5  
Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M (2022) Standard Specification for Gray  
Iron Castings

ASTM B1 (2013) Standard Specification for  
Hard-Drawn Copper Wire

ASTM B3 (2013; R 2024) Standard Specification for  
Soft or Annealed Copper Wire

ASTM B8 (2023) Standard Specification for  
Concentric-Lay-Stranded Copper Conductors,  
Hard, Medium-Hard, or Soft

ASTM B496 (2016; R 2021) Standard Specification for  
Compact Round Concentric-Lay-Stranded  
Copper Conductors

ASTM C32 (2023) Standard Specification for Sewer  
and Manhole Brick (Made from Clay or Shale)

ASTM C139 (2023) Standard Specification for Concrete  
Masonry Units for Construction of Catch  
Basins and Manholes

ASTM C309 (2019) Standard Specification for Liquid  
Membrane-Forming Compounds for Curing  
Concrete

ASTM C478M (2018) Standard Specification for Precast  
Reinforced Concrete Manhole Sections  
(Metric)

ASTM C857 (2016) Standard Practice for Minimum  
Structural Design Loading for Underground  
Precast Concrete Utility Structures

ASTM C990M (2009; R 2019) Standard Specification for  
Joints for Concrete Pipe, Manholes, and  
Precast Box Sections Using Preformed  
Flexible Joint Sealants (Metric)

ASTM F2160 (2022a) Standard Specification for Solid  
Wall High Density Polyethylene (HDPE)  
Conduit Based on Controlled Outside  
Diameter (OD)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 48 (2020) Test Procedures and Requirements  
for Alternating-Current Cable Terminations  
Used on Shielded Cables Having Laminated



	Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE 400.2	(2024) 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 495	(2007) Guide for Testing Faulted Circuit Indicators
IEEE C2	(2023) 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	(2021) Concentric Neutral Cables Rated 5 Through 46 KV
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INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2025) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
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NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2023) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
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	(2018) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 7	(2021) Smooth-Wall Coilable and Straight Electrical Polyethylene Conduit
NEMA TC 9	(2020) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation
NEMA WC 74/ICEA S-93-639	(2022) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA 70	(2026) National Electrical Code
SOCIETY OF CABLE TELECOMMUNICATIONS ENGINEERS (SCTE)	
ANSI/SCTE 77	(2013) Specification for Underground Enclosure Integrity
TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)	
TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard
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
UL SOLUTIONS (UL)	
UL 6	(2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 94	(2023; Reprint Jan 2024) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2025) UL Standard for Safety Wire Connectors
UL 510	(2020; Dec 2022) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2024) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint Mar 2024) UL Standard for Safety Conduit, Tubing and Cable Fittings
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 854	(2020; Reprint Jul 2024) Standard for Service-Entrance Cables
UL 1072	(2006; Reprint Oct 2024) Medium-Voltage Power Cables
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel

KOREAN INDUSTRIAL STANDARDS (KS)

KS C 8401	(2016; R 2021) Rigid Steel Conduits
KS C 8431	(2014; R 2024) Rigid Unplasticized Polyvinyl Chloride (UPVC) Conduit
KS C 8433	(2005; R 2025) Couplings for Rigid PVC Conduit Tubes
KS C 8434	(2005; R 2025) Connectors for Rigid PVC Conduit Tubes
KS C 8458	(2012; R 2022) Box and Box Cover for Rigid Metal Conduits
KS C 8460	(2005; R 2025) Fittings for Rigid Metal Conduits
KS C 8461	(2005; R 2025) Surface Accessory for Rigid Metal Conduits

[1.2 SYSTEM DESCRIPTION

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**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 3-301-01, "Structural Engineering" and Sections 13 48 73 SEISMIC CONTROL FOR NONSTRUCTURAL COMPONENTS and 26 05 48 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT properly edited, must be included in the contract documents.

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Items provided under this section must be specifically suitable for the following service conditions. Seismic details must [conform to UFC 3-301-01, "Structural Engineering" and Sections 13 48 73 SEISMIC CONTROL FOR NONSTRUCTURAL COMPONENTS and 26 05 48 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT] [be as indicated].

- a. Fungus Control [\_\_\_\_\_]
- b. Altitude [\_\_\_\_\_] m.
- c. Ambient Temperature [\_\_\_\_\_] degrees C.
- d. Frequency [\_\_\_\_\_]
- e. Ventilation [\_\_\_\_\_]
- f. Seismic Parameters [\_\_\_\_\_]
- g. Humidity Control [\_\_\_\_\_]
- h. Corrosive Areas [\_\_\_\_\_]
- i. [\_\_\_\_\_]

#### ]1.3 RELATED REQUIREMENTS

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**NOTE: Include Section 26 08 00 APPARATUS INSPECTION AND TESTING on all projects involving medium voltage and grounding systems.**

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Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

#### 1.4 DEFINITIONS

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

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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 of runway sideline
  - b) On or within 15 m 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".

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

#### ]1.5 SUBMITTALS

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NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified 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 Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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 and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification

and as described in Section 01 33 00 SUBMITTAL  
PROCEDURES.

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

SD-02 Shop Drawings

Precast Underground Structures; G

SD-03 Product Data

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

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Medium Voltage Cable; G

Medium Voltage Cable Joints; G

Medium Voltage Cable Terminations; G

[ Live End Caps; G

] Precast Concrete Structures; G

Sealing Material

Pulling-In Irons

Manhole Frames and Covers; G

Handhole Frames and Covers; G

[ Frames and Covers for Airfield Facilities; G

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

] Composite/Fiberglass Handholes; G

Cable Supports (racks, arms and insulators); G

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

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[ Protective Devices and Coordination Study; G

][ Submit the study 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 will be based on recommendations of this study. The Government will not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered or procured prior to approval of the study.

] SD-06 Test Reports

Medium Voltage Cable Qualification and Production Tests; G

Field Acceptance Checks and Tests; G

Arc-proofing Test for cable fireproofing tape; G

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NOTE: Use Cable Installation only when pulling  
cable between manholes; do not use for pulling from  
pole riser to manhole only.  
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[ Cable Installation Plan and Procedure; G

[[ Five copies of the information described below in 215.9 by 279.4 mm 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

Cable Installer Qualifications; G

[ Directional Boring Certificate of Conformance; G

]1.6 QUALITY ASSURANCE

1.6.1 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 MNL-66
- e. Plans and elevations showing opening and pulling-in iron locations and details

[1.6.2 Certificate of Competency for Cable Splicer/Terminator

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**NOTE: Delete this paragraph if there is no medium voltage work required for the project. For CONUS projects, select the first bracketed paragraph. For OCONUS projects, select the second bracketed paragraph.**  
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Submit certification of the qualification of the cable splicer/terminator for approval, 30 days before splices or terminations are to be made in medium voltage (5 kV to 35 kV) cables. Include the training, and experience of the individual on the specific type and classification of cable to be provided under this contract. Indicate that the individual has had three or more years recent experience splicing and terminating medium voltage cables. List a minimum of three splices/terminations that have been in operation for more than one year. In addition, the individual may be required to perform a dummy or practice splice/termination in the presence of the Contracting Officer, before being approved as a qualified cable splicer. If that additional requirement is imposed, the Contractor must provide short sections of the approved types of cables along with the approved type of splice/termination kit, and detailed manufacturer's instructions for the cable to be spliced. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for certification of an alternate cable splicer.

[1.6.3 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.

[1.6.4 Directional Boring Certificate of Conformance

\*\*\*\*\*  
**NOTE: Delete this paragraph if there is no directional boring work required for the project.**  
\*\*\*\*\*



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.

#### 1.6.5 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.

#### 1.6.6 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.

##### 1.6.6.1 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.

##### 1.6.6.2 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](#) or [KS C 8401](#).

##### 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](#) at 60 Hz, and tensile strength must be minimum [25 MPa](#).

2.1.2 Intermediate Metal Conduit

UL 1242.

2.1.3 Plastic Conduit for Direct Burial and Riser Applications

\*\*\*\*\*  
NOTE: Specify EPC-40-PVC or EPC-80-PVC for  
direct-burial and riser applications.  
\*\*\*\*\*

UL 651 and NEMA TC 2, EPC-40, EPC-80, or KS C 8431 HI-VE type, unless  
indicated otherwise..

2.1.4 Plastic Duct for Concrete Encasement

\*\*\*\*\*  
NOTE: Choose EB-35 where conduit deformity is a  
concern. Choose EPC-40 where required by the  
activity. Include "as indicated" when drawings  
designate different applications, such as, Type EB  
for primary distribution and Type EPC for secondary  
distribution to avoid transitions for risers.  
\*\*\*\*\*

UL 651 and NEMA TC 2, EPC-40, EPC-80, or KS C 8431 HI-VE type, unless  
indicated otherwise..

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

\*\*\*\*\*  
NOTE: Delete this paragraph if there is no  
directional boring work required for the project.  
\*\*\*\*\*

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

]2.1.6 Duct Sealant

UL 94, Class HBF. Provide high-expansion urethane foam duct sealant that  
expands and hardens to form a closed, chemically and water resistant,  
rigid structure. Sealant must be compatible with common cable and wire  
jackets and capable of adhering to metals, plastics and concrete. Sealant  
must be capable of curing in temperature ranges of 2 degrees C to 35  
degrees C. Cured sealant must withstand temperature ranges of -29 degrees  
C to 93 degrees C without loss of function.

2.1.7 Fittings

2.1.7.1 Metal Fittings

UL 514B or KS C 8460 and KS C 8461.

2.1.7.2 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 or KS C 8433 and KS C 8434]][NEMA TC 3].

#### 2.1.7.3 PVC Duct Fittings

NEMA TC 9 or KS C 8433 and KS C 8434.

#### 2.1.7.4 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 or KS C 8458.

### 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. Wires and cables manufactured more than 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. 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.

#### [2.2.3 Jackets

Provide multiconductor cables with an overall PVC outer jacket.

#### ]2.2.4 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.

#### 2.2.5 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 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.

Color code conductors. 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. Properly identify control circuit terminations. 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 may be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems are 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

## 2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

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**.

## 2.4 LOW VOLTAGE SPLICES

\*\*\*\*\*  
**NOTE: ANSI C119.1 Section 6.2.1.3 requires all connector systems be immersed in water for 24 hours at a minimum depth of 12 inches. Select splices that conform to this requirement.**  
\*\*\*\*\*

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]. 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 133 percent insulation level.

## 2.5.2 Conductor Material

\*\*\*\*\*

NOTE: Provide aluminum conductors for new underground circuits and extensions of existing circuits. Select Type AA-8000 for type MV cable. Select 1350 for "UD/URD" cable. 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 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 for Army and Air Force project. XLP Type MV cable is not allowed for Navy or Marine Corps projects.

For non-shielded cables rated 2001-5000 volts, choose ANSI/NEMA WC 71/ICEA S-96-659. For cables rated >15kV, choose ANSI/NEMA WC 74/ICEA S-93-639.

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

\*\*\*\*\*

Provide tree-retardant cross-linked thermosetting polyethylene (XLP) insulation conforming to the requirements of NEMA WC 74/ICEA S-93-639 and AEIC CS8.

### 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 tailored for ARMY and AIR FORCE, 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, employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable. 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 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.[ 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. Provide terminations, where required, with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Provide terminations 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). Design termination 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. Design termination 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 may 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. Do not use separable connectors 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.  
]

\*\*\*\*\*  
**NOTE: Include the following paragraph only when the  
activity requires faulted circuit indicators.**  
\*\*\*\*\*

[ d. Install one set of faulted circuit indicators, complying with IEEE 495,  
on the test points of each set of separable insulated connectors.  
Indicators must be self powered; with automatic trip with mechanical  
flag indication upon overcurrent followed by loss of system voltage,  
and automatic reset upon restoration of system voltage. Indicators  
must be compact, sealed corrosion resistant construction with  
provision for hotstick installation and operation.

]]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 should 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. Conform to applicable portions of IEEE 48.

## 12.10 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

Provide detectable tape in accordance with Section 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 thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, adhesive-free, 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.

## 2.12 GROUNDING AND BONDING

### 2.12.1 Driven Ground Rods

\*\*\*\*\*  
**NOTE: Provide solid copper ground rods when soil conditions are corrosive.**  
\*\*\*\*\*

Provide [copper-clad steel ground rods conforming to UL 467][solid copper ground rods conforming to UL 467][solid stainless steel ground rods] not less than 19 mm in diameter by 3.1 m in length. Sectional type rods may be used for rods 62 m 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: Retain Section 03 30 00 CAST-IN-PLACE  
CONCRETE for Navy projects and Section 03 30 00  
CAST-IN-PLACE CONCRETE for Army projects.**  
\*\*\*\*\*

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. In addition, provide concrete for encasement of underground ducts with 20 MPa minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts must be 30 MPa 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**  
**<https://www.wbdg.org/dod/ufgs/ufgs-forms-graphics-tables>.**  
**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. 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.[  
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. 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
- b. Unit Weight of Soil (Dry) = 1760 kg/m<sup>3</sup>, (Saturated)  
= 2080 kg/m<sup>3</sup>
- c. Coefficient of Lateral Earth Pressure ( $K_a$ ) = 0.33
- d. Ground Water Level = 915 mm 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. Design decks and  
covers subject to aircraft loadings for loadings per  
FAA AC-150/5320-6 except as follows:

- a. Design covers for 45 000 kg wheel loads with  
1.72 MPa tire pressure.

b. For spans of less than 0.6 m in the least direction, use a uniform live load of 2.24 Mpa.

c. For spans of 0.6 m or greater in the least direction, base the design on the number of wheels which will fit the span. Use wheel loads of 34,000 kg.

\*\*\*\*\*

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.

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

Provide a uniform thickness for structure top, bottom, and wall not less than 150 mm. 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 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 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 in diameter and 100 mm 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. 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. Provide rolled-steel floor plate covers having an approved antislip surface. Hinges must be of [stainless steel with bronze hinge pin] [wrought steel], **125 by 125 mm** by approximately **4.75 mm** 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 Manhole Ladder

Provide Ladder [, corrosion protected ,Permanent, and width minimum 304mm][as indicated].

#### [2.14.6 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**. Provide rolled steel floor plate covers having an approved anti-slip surface. Steel frames and covers must be hot dipped galvanized after fabrication.

#### ]2.14.7 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** 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.

2.14.8 Brick for Manhole Collar

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

2.14.9 Composite/Fiberglass Handholes and Covers

ANSI/SCTE 77. Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass with a design load (Tier rating) appropriate for or greater than the intended use. All covers are required to have the Tier level rating embossed on the surface which must not exceed the design load of the box.

2.15 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

Zinc coat the metal portion of racks and arms after fabrication.

2.15.1 Cable Rack Stanchions

The wall bracket or stanchion must be 100 mm by approximately 38 mm by 4.76 mm channel steel, or 100 mm by approximately 25 mm glass-reinforced nylon with recessed bolt mounting holes, 1220 mm long (minimum) in manholes. Space slots for mounting cable rack arms at 200 mm 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 and a maximum of 305 mm.

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 polyethylene tags for each power cable located in manholes. Do not provide handwritten letters. The first position on the power cable tag denotes the voltage. The second through sixth positions on the tag identifies the circuit. The next to last position denotes the phase of the circuit and include the Greek "phi" symbol. The last position denotes 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 having an average tensile strength of 22.4 MPa; and that are 2 millimeter thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 77 degrees C. Provide 1.3 mm (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag, having a minimum loop tensile strength of 778.75 N and black block letters, numbers, and symbols 25 mm 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, 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. Provide

pedestal with rust-free material and stainless steel hardware that is 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 05 73 POWER SYSTEM STUDIES 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 05 73 POWER SYSTEM STUDIES.

## 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 long with a 65.5 mm outside diameter, and a 3.175 mm 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. Direct the arc 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). Test each sample assembly 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 should conform to Section 31 31 16.13 CHEMICAL TERMITE CONTROL, except that application to direct burial cable installation should 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. For projects with direct-buried cable (not in conduit) and at project locations in Environmental Severity Classifications (ESC) C4 and C5, treat soil a minimum 305 mm on each side for the entire length of the cable. For these projects include the last bracketed sentence in the paragraph below, and edit and include Section 31 31 16.13 CHEMICAL TERMITE CONTROL. See UFC 1-200-01 for determination of ESC for project location.

\*\*\*\*\*

\*\*\*\*\*

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.

\*\*\*\*\*

\*\*\*\*\*

NOTE: Electrical Identification Standard of Interior/Exterior Electrical Distribution Systems shall be attached and enforced to label/mark all the electrical systems and provide O&M data in accordance with the standard for Kunsan AB Projects. Include the first bracket for KUNSAN AB projects only.

\*\*\*\*\*

[ Records for O&M data and Labels/Marks on all installed electrical systems shall be provided in accordance with Electrical Identification Standard as attached.

]

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.[ Treat soil a minimum 305 mm on each side of the installed cable for the entire length in accordance with Section 31 31 16.13 CHEMICAL TERMITE CONTROL.]

### 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. Do not specify  
IMC/aluminum in corrosive locations. Corrosive  
locations are those with Environmental Severity  
Classifications (ESC) of C3 thru C5. See UFC  
1-200-01 for determination of ESC for project  
locations.  
\*\*\*\*\*

Terminate underground feeders supplying building at a point 1525 mm  
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 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. 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. 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 of level, 90 percent compacted granular fill, 19 mm to 25 mm size, extending 305 mm 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, locate the irons a minimum of 150 mm from the edge of the sump, and in the walls, locate the irons within 150 mm 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 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 clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 915 mm 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 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 and must be designed to withstand a minimum pulling-in load of 26,700 N. Hot-dip galvanize irons 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 apart, and provide each manhole wall with a minimum of two racks. Space racks in signal manholes not more than 420 mm apart with the end rack being no further than 305 mm from the adjacent wall. Methods of anchoring cable racks are as follows:

- a. Provide a 15 mm diameter by 125 mm long anchor bolt with 75 mm foot cast in structure wall with 50 mm protrusion of threaded portion of

bolt into structure. Provide 15 mm 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. Insert channel must be steel of the same length as "vertical rack channel;" and cast flush in structure wall. Provide 15 mm steel nuts in channel insert to receive 15 mm diameter by 75 mm 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 load rating. Provide 15 mm diameter by 75 mm 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.  
\*\*\*\*\*

Clean cast-iron frames and covers not buried in concrete or masonry of mortar, rust, grease, dirt and other deleterious materials, and coat with bituminous paint.

## 3.6 UNDERGROUND CONDUIT AND DUCT SYSTEMS

### 3.6.1 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. Placement of grounding conductor below duct  
bank is preferred since it will be physically  
protected by the concrete encasement; however,  
coordinate with the Activity regarding placement  
below or above duct bank.  
\*\*\*\*\*

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Provide a 4/0 AWG bare copper grounding conductor [below][above] medium-voltage distribution duct banks. Bond bare copper grounding conductor to ground rings (loops) in all manholes and to ground rings (loops) at all equipment slabs (pads). Route grounding conductor into manholes with the duct bank (sleeving is not required). 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. 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. Terminate all PVC conduit end points in utility holes, switching cabinets, transform handholes and buildings with end bells. The bell end of the conduits that enter manholes and handholes must be flush with the wall.

Perform changes in ductbank direction as follows:

- a. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable.
- b. The minimum manufactured bend radius must be 450 mm for ducts of less than 80 mm diameter, and 900 mm for ducts 80 mm or greater in diameter.
- c. As an exception to the bend radius required above, provide field manufactured longsweep bends having a minimum radius of 7.6 m for a change of direction of more than 5 degrees, either horizontally or vertically, using a combination of curved and straight sections. Maximum manufactured curved sections allowed for use in field manufactured longsweep bend: 30 degrees.

### 3.6.2 Treatment

Keep ducts clean of concrete, dirt, or foreign substances during construction. Make field cuts requiring tapers with proper tools and match factory tapers. Use a coupling recommended by the duct manufacturer whenever an existing duct is connected to a duct of different material or shape. Store ducts to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Thoroughly clean ducts before being laid. Store plastic ducts on a flat surface and protected from the direct rays of the sun.

### 3.6.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 75 mm and larger, draw a flexible testing mandrel approximately 305 mm 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, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

### 3.6.4 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, install rigid steel conduit 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 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 on centers.[ Hydraulic jet method must not be used.]

### [3.6.5 Galvanized Conduit Concrete Penetrations

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



### 13.6.6 Multiple Conduits

Separate multiple conduits by a minimum distance of 75 mm[, except that light and power conduits must be separated from control, signal, and telephone conduits by a minimum distance of [300] mm]. 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 of conduit assembly.

### 3.6.7 Conduit Plugs and Pull Rope

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

### 3.6.8 Conduit and Duct Without Concrete Encasement

[Depths to top of the conduit must be not less than 610 mm below finished grade.][Install conduit and ducts with the depths as indicated.] Provide not less than 75 mm 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, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 6.25 mm sieve. The first 150 mm 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 layers. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

#### 3.6.8.1 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 concrete cover around ducts. Extend concrete encasement at least 1525 mm beyond the edges of paved areas and roads, and 3660 mm beyond the rails on each side of railroad tracks. [Depths to top of the concrete envelope must be not less than 610 mm below finished grade[, and under railroad tracks not less than 1270 mm below the top of the rails]] [Install conduit and ducts with the depths as indicated.].

#### 3.6.8.2 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 in pavement-covered areas and not less than 3050 mm 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 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 in pavement- or non-pavement-covered areas.]

]3.6.9 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 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 and <1220 mm	Undeveloped areas.	Transition from good to poor soil conditions where differential settlement is anticipated.
>610 mm and <1220 mm	Roads/paved areas for light to moderate traffic loads.	Other roads/paved areas (i.e. supporting trucks, cranes, ultra-heavy loads.)
>1220 mm	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 w/ #10 ties at 915 mm o/c for ductbanks 760 mm or less wide.
- \* Use minimum reinforcement of 6 #13 w/ #10 ties at 915 mm o/c for ductbanks greater than 760 mm 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 below finished grade[, except under roads and pavement, concrete envelope must be not less than 610 mm below finished grade][, and under railroad tracks not less than 1270 mm below the top of the rails]][Install conduit and ducts with the depths as indicated]. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank must be rectangular in cross-section and provide at least 75 mm of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 75 mm. Before pouring concrete, anchor duct bank assemblies, prevent floating during concrete pouring 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.]

#### 3.6.9.1 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 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.

#### 3.6.9.2 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.

#### 3.6.9.3 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.

#### 3.6.9.4 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.]

#### 3.6.9.5 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 back into the envelope and a minimum of 610 mm beyond the end of the envelope. Provide one No. 4 bar in each corner, 75 mm from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 305 mm apart. Restrain reinforcing assembly from moving during concrete pouring.

#### [3.6.9.6 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.

#### ]3.6.10 Duct Sealing

Seal all electrical penetrations for radon mitigation, maintaining integrity of the vapor barrier, and to prevent infiltration of air, insects, and vermin.

### 3.7 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.

#### 3.7.1 Cable Lubricants

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

### 3.8 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.

#### 3.8.1 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.

### 3.9 CONDUCTORS INSTALLED IN PARALLEL

Group conductors such that each conduit of a parallel run contains one Phase A conductor, one Phase B conductor, one Phase C conductor, and one neutral conductor.

#### 3.10 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 MEDIUM VOLTAGE CABLE TERMINATIONS

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

#### 3.12 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.

##### 3.12.1 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 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.

#### [3.14 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.

#### ]3.15 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

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

##### 3.15.1 Fireproofing Tape

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

##### [3.15.2 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 thick plastic tape, and must extend not less than 25 mm into the duct. Even out irregularities of the cable, such as at splices, with insulation putty before applying tape.

#### ]3.16 GROUNDING SYSTEMS

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

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

### 3.16.1 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 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][ 300 mm], installed to provide an earth ground of the appropriate value for the particular equipment being grounded.

If the specified ground resistance is not met, provide an additional ground rod 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.

### 3.16.2 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.

### 3.16.3 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.]

### 3.16.4 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.

### 3.16.5 Manhole Grounding

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately 305 mm above finished floor. Secure the conductor to the manhole walls at intervals not exceeding 914 mm. 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.

### [3.16.6 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 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 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. Bond each gate section to its gatepost by a 3 by 25 mm flexible braided copper strap and ground post clamps. Clamps must be of the anti-electrolysis type.

### ]3.16.7 Metal Splice Case Grounding

Ground metal splice cases for medium-voltage direct-burial cable by connection to a driven ground rod located within 600 mm 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.

### ]3.17 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 00 00 EARTHWORK.

### 3.17.1 Reconditioning of Surfaces

#### 3.17.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct . 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.]

#### 3.17.1.2 Paving Repairs

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**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][\_\_\_\_].]

### 3.18 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

#### 3.18.1 Concrete Slabs (Pads) for Equipment

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

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

#### [3.18.2 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.

### ]3.19 FIELD QUALITY CONTROL

#### 3.19.1 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.

### 3.19.1.1 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)

#### 3.19.1.2 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.

#### 3.19.1.3 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 ground

resistance 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. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

### 3.19.2 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 --