
USACE / NAVFAC / AFCEA / NASA UFGS-33 71 02.00 20 (February
2007)

Preparing Activity: NAVFAC Superseding
2007) UFGS 33 71 02.00 20 (January

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 19 March 2007

Latest change indicated by CHG tags

SECTION TABLE OF CONTENTS

DIVISION 33 - UTILITIES

SECTION 33 71 02.00 20

UNDERGROUND ELECTRICAL DISTRIBUTION

02/07

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 DEFINITIONS
- 1.3 SUBMITTALS
- 1.4 QUALITY ASSURANCE
 - 1.4.1 Precast Underground Structures
 - 1.4.2 Certificate of Competency for Cable Splicer/Terminator
 - 1.4.3 Cable Installer Qualifications
 - 1.4.4 Regulatory Requirements
 - 1.4.5 Standard Products
 - 1.4.5.1 Alternative Qualifications
 - 1.4.5.2 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
 - 2.1.2.1 Intermediate Metal Conduit, PVC Coated
 - 2.1.3 Plastic Conduit for Direct Burial
 - 2.1.4 Plastic Duct for Concrete Encasement
 - 2.1.5 Bituminized Fiber Duct
 - 2.1.6 Innerduct
 - 2.1.7 Conduit Sealing Compound
 - 2.1.8 Fittings
 - 2.1.8.1 Metal Fittings
 - 2.1.8.2 PVC Conduit Fittings
 - 2.1.8.3 PVC Duct Fittings
 - 2.1.8.4 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 Direct Buried
- 2.2.5 In Duct
- 2.2.6 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 Frames and Covers for Airfield Facilities
 - 2.14.6 Ductile Iron Frames and Covers for Airfield Facilities
 - 2.14.7 Brick for Manhole Collar
 - 2.14.8 Composite/Fiberglass Handholes and Covers
- 2.15 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)
 - 2.15.1 Cable Racks
 - 2.15.2 Rack Arms
 - 2.15.3 Insulators
- 2.16 CABLE TAGS IN MANHOLES
 - 2.16.1 Polyethylene Cable Tags
- 2.17 CABLE TERMINATING CABINETS
- 2.18 PROTECTIVE DEVICES AND COORDINATION
- 2.19 SOURCE QUALITY CONTROL
 - 2.19.1 Arc-Proofing Test for Cable Fireproofing Tape
 - 2.19.2 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 DIRECT BURIAL CABLE SYSTEM
 - 3.6.1 Trenching
 - 3.6.2 Cable Installation.
 - 3.6.3 Splicing
 - 3.6.4 Bends
 - 3.6.5 Horizontal Slack
 - 3.6.6 Identification Slabs [Markers]
- 3.7 UNDERGROUND CONDUIT AND DUCT SYSTEMS
 - 3.7.1 Requirements
 - 3.7.2 Treatment
 - 3.7.3 Conduit Cleaning
 - 3.7.4 Jacking and Drilling Under Roads and Structures
 - 3.7.5 Galvanized Conduit Concrete Penetrations
 - 3.7.6 Multiple Conduits
 - 3.7.7 Conduit Plugs and Pull Rope
 - 3.7.8 Conduit and Duct Without Concrete Encasement
 - 3.7.8.1 Encasement Under Roads and Structures
 - 3.7.9 Duct Encased in Concrete
 - 3.7.9.1 Connections to Manholes
 - 3.7.9.2 Connections to Existing Underground Structures
 - 3.7.9.3 Connections to Existing Concrete Pads
 - 3.7.9.4 Connections to Existing Ducts
 - 3.7.9.5 Partially Completed Duct Banks
 - 3.7.9.6 Removal of Ducts
- 3.8 CABLE PULLING
 - 3.8.1 Cable Lubricants
- 3.9 CABLES IN UNDERGROUND STRUCTURES
 - 3.9.1 Cable Tag Installation
- 3.10 CONDUCTORS INSTALLED IN PARALLEL
- 3.11 LOW VOLTAGE CABLE SPLICING AND TERMINATING
 - 3.11.1 Terminating Aluminum Conductors
- 3.12 MEDIUM VOLTAGE CABLE TERMINATIONS
- 3.13 MEDIUM VOLTAGE CABLE JOINTS
 - 3.13.1 Joints in Shielded Cables
- 3.14 CABLE END CAPS
- 3.15 LIVE END CAPS
- 3.16 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES
 - 3.16.1 Fireproofing Tape
 - 3.16.2 Tape-Wrap
- 3.17 GROUNDING SYSTEMS
 - 3.17.1 Grounding Electrodes
 - 3.17.2 Grounding Connections
 - 3.17.3 Grounding Conductors
 - 3.17.4 Ground Cable Crossing Expansion Joints
 - 3.17.5 Manhole Grounding
 - 3.17.6 Fence Grounding

- 3.18 EXCAVATING, BACKFILLING, AND COMPACTING
 - 3.18.1 Reconditioning of Surfaces
 - 3.18.1.1 Unpaved Surfaces
 - 3.18.1.2 Paving Repairs
- 3.19 CAST-IN-PLACE CONCRETE
 - 3.19.1 Concrete Slabs for Equipment
 - 3.19.2 Sealing
- 3.20 FIELD QUALITY CONTROL
 - 3.20.1 Performance of Field Acceptance Checks and Tests
 - 3.20.1.1 Medium Voltage Cables
 - 3.20.1.2 Grounding System
 - 3.20.2 Follow-Up Verification

-- End of Section Table of Contents --

USACE / NAVFAC / AFCEA / NASA UFGS-33 71 02.00 20 (February
2007)

Preparing Activity: NAVFAC Superseding
2007) UFGS 33 71 02.00 20 (January

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 19 March 2007

Latest change indicated by CHG tags

SECTION 33 71 02.00 20

UNDERGROUND ELECTRICAL DISTRIBUTION 02/07

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

Edit this guide specification for project specific
requirements by adding, deleting, or revising text.
For bracketed items, choose applicable items(s) or
insert appropriate information.

Remove information and requirements not required in
respective project, whether or not brackets are
present.

Comments and suggestions on this guide specification
are welcome and should be directed to the technical
proponent of the specification. A listing of
technical proponents, including their organization
designation and telephone number, is on the Internet.

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

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

Note: This section use the following manhole / handhole sketches and details. These are located on the WBDG, in the CCB: Specifications Library/NAVFAC Specifications/UFGS and Navy Regional Specifications Graphics.

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)

NOTE: TO DOWNLOAD UFGS GRAPHICS

Go to <http://www.wbdg.org/ccb/NAVGRAPH/graphdoc.pdf>.

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

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

2. Location of ducts, and cables.

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

4. Special conditions.

PART 1 GENERAL

1.1 REFERENCES

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

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

ACI INTERNATIONAL (ACI)

ACI 318M (2005) Metric Building Code Requirements for Structural Concrete and Commentary

ACI SP-66 (2004) ACI Detailing Manual

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

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

AASHTO M 198 (2005) Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C135.30 (1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2006; Errata 2006) Structural Welding Code - Steel

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8 (2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A 48/A 48M	(2003) Gray Iron Castings
ASTM B 1	(2001) Hard-Drawn Copper Wire
ASTM B 231/B 231M	(2004) Concentric-Lay-Stranded Aluminum 1350 Conductors
ASTM B 3	(2001) Soft or Annealed Copper Wire
ASTM B 400	(2004) Compact Round Concentric-Lay-Stranded Aluminum 1350 Conductor
ASTM B 496	(2004) Compact Round Concentric-Lay-Stranded Copper Conductors
ASTM B 609/B 609M	(1999; R 2004) Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical purposes
ASTM B 8	(2004) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B 800	(2005) 8000 Series Aluminum Alloy Wire for Electrical Purposes-Annealed and Intermediate Tempers
ASTM B 801	(1999) Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation
ASTM C 139	(2005) Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C 309	(2006) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 32	(2005) Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C 478	(2006b) Precast Reinforced Concrete Manhole Sections
ASTM C 478M	(2006b) Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C 857	(1995; R 2001) Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM F 512	(1995; R 2001e1) Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2005) National Electrical Safety Code
IEEE C37.20.3	(2001) Metal-Enclosed Interrupter Switchgear
IEEE Std 100	(2000) The Authoritative Dictionary of IEEE Standards Terms
IEEE Std 386	(1995) Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE Std 400.2	(2004) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)
IEEE Std 404	(2000) Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V Through 500 000 V
IEEE Std 48	(1996; R 2003) Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1) Normal Measurements

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-94-649	(2004) Standard for Concentric Neutral Cable Rated 5 Through 46 KV
---------------	--

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2003) Acceptance Testing Specifications
----------	--

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C119.1	(2002) Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA RN 1	(2005) Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2003) Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
NEMA TC 3	(2004) Polyvinyl Chloride PVC Fittings for Use with Rigid PVC Conduit and Tubing
NEMA TC 6 & 8	(2003) Polyvinyl Chloride PVC Plastic Utilities Duct for Underground Installations

NEMA TC 7 (2005) Smooth-Wall Coilable Polyethylene Electrical Plastic Duct

NEMA TC 9 (2004) Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation

NEMA WC 70 (1999; Errata 2001) Non-Shielded Power Cables Rated 2000 Volts or less for the Distribution of Electrical Energy

NEMA WC 71 (1999) Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy

NEMA WC 74 (2000) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2005; TIA 2005) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758-A (2004) Customer-Owned Outside Plant Telecommunications Cabling 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 1) Frames, Covers, Gratings, Steps, Sump And Catch Basin, Manhole

UNDERWRITERS LABORATORIES (UL)

UL 1072 (2006; Rev thru Oct 2006) Medium-Voltage Power Cables

UL 1242 (2006; Rev thru Jun 2006) Electrical Intermediate Metal Conduit -- Steel

UL 1684 (2000; Rev thru Aug 2004) Reinforced Thermosetting Resin Conduit (RTRC) and Fittings

UL 44 (2005; Rev thru Nov 2005) Thermoset-Insulated Wires and Cables

UL 467 (2004) Grounding and Bonding Equipment

UL 486A-486B (2003; Rev thru Aug 2006) Wire Connectors

UL 510 (2005; Rev thru Aug 2005) Polyvinyl Chloride, Polyethylene, and Rubber

Insulating Tape

UL 514A	(2004; Rev thru Aug 2005) Metallic Outlet Boxes
UL 514B	(2004; Rev thru Apr 2006) Conduit, Tubing and Cable Fittings
UL 6	(2004) Electrical Rigid Metal Conduit - Steel
UL 651	(2005; Rev thru Dec 2006) Schedule 40 and 80 Rigid PVC Conduit
UL 651A	(2000; Rev thru Sep 2003) Type EB and A Rigid PVC Conduit and HDPE Conduit
UL 83	(2003; Rev thru Apr 2006) Thermoplastic-Insulated Wires and Cables
UL 854	(2004) Service-Entrance Cables

1.2 DEFINITIONS

- a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in **IEEE Std 100**.
- b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.
- c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

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

1. For fixed wing aircraft facilities:
 - a) On or within **200 feet 61 m** of runway sideline
 - b) On or within **50 feet 15 m** of taxiway or apron sideline
 - c) Within Type 1 clear zone area as defined by NAVFAC Publication P-971 "Airfield & Heliport Planning & Design" dated March 1998.
2. For rotary wing aircraft facilities:
 - a) On landing surfaces, primary surfaces, or within areas defined as "paved and unpaved shoulders" in NAVFAC Publication P-971 "Airfield & Heliport Planning & Design" dated March 1998.

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

1.3 SUBMITTALS

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

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

SD-03 Product Data

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

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

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

Medium voltage cable terminations[; G][; G, [____]]
Live end caps[; G][; G, [____]]
Precast concrete structures[; G][; G, [____]]
Sealing Material
Pulling-In Irons
Manhole frames and covers[; G][; G, [____]]
Handhole frames and covers[; G][; G, [____]]
[Frames and Covers for Airfield Facilities[; G][; G, [____]]]
[Ductile Iron Frames and Covers for Airfield Facilities[; G][; G, [____]]]
Composite/fiberglass handholes[; G][; G, [____]]
Cable supports (racks, arms and insulators)[; G][; G, [____]]

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

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

[The study shall be submitted with protective device equipment submittals. No time extension or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed shall be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.]

SD-06 Test Reports

Arc-proofing test for cable fireproofing materials[; G][; G, [____]]
Medium voltage cable qualification and production tests[; G][; G, [____]]
Field Acceptance Checks and Tests; G
Arc-proofing test for cable fireproofing tape[; G][; G, [____]]

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

Cable Installation Plan and Procedure

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

- a. Site layout drawing with cable pulls numerically identified.
- b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.
- c. The cable manufacturer and type of cable.
- d. The dates of cable pulls, time of day, and ambient temperature.
- e. The length of cable pull and calculated cable pulling tensions.
- f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

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

Cable Installer Qualifications

1.4 QUALITY ASSURANCE

1.4.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

- a. Material description (i.e., f'c and Fy)
- b. Manufacturer's printed assembly and installation instructions
- c. Design calculations
- d. Reinforcing shop drawings in accordance with ACI SP-66
- e. Plans and elevations showing opening and pulling-in iron locations and details

1.4.2 Certificate of Competency for Cable Splicer/Terminator

Certification of the qualification of the cable splicer/terminator shall be submitted, for approval, 30 days before splices or terminations are to be made in medium voltage (5 kV to 35 kV) cables. The certification shall include the training, and experience of the individual on the specific type and classification of cable to be provided under this contract. The certification shall indicate that the individual has had three or more years recent experience splicing and terminating medium voltage cables. The certification shall also 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 shall 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.

1.4.3 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.

1.4.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" 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 shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.5 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 shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on 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 shall 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.

1.4.5.1 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.

1.4.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

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

2.1.2 Intermediate Metal Conduit

UL 1242.

2.1.2.1 Intermediate Metal Conduit, PVC Coated

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

2.1.3 Plastic Conduit for Direct Burial

NOTE: Specify EPC-40-PVC or EPC-80-PVC for direct-burial and riser applications. Choose UL 651 where conduit is required to be in compliance with NFPA 70 and for most applications. Choose NEMA TC 2 when conduit size is greater than 6 inches.

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

2.1.4 Plastic Duct for Concrete Encasement

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

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

NEMA TC 6 & 8 and ASTM F 512, [UL 651A Type EPC-20-PVC] [Type EPC-35-PVC] [UL 651, EPC-40-PVC] [or] [as indicated].

[2.1.5 Bituminized Fiber Duct

NOTE: Do not use for Navy projects.

For Army and Air Force projects, bituminized fiber duct should be specified only for connection to existing bituminized fiber duct systems.

UL 1684 for [Type I (Thinwall)][Type II (Thickwall)].

]2.1.6 Innerduct

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

2.1.7 Conduit Sealing Compound

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

2.1.8 Fittings

2.1.8.1 Metal Fittings

UL 514B.

2.1.8.2 PVC Conduit Fittings

NOTE: Choose UL listed fittings for most applications and where conduit is required to comply with NFPA 70.

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

2.1.8.3 PVC Duct Fittings

NEMA TC 9.

[2.1.8.4 Outlet Boxes for Steel Conduit

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

]2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

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

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

2.2.1 Conductor Types

Cable and duct sizes indicated are for copper conductors and THHN/THWN unless otherwise noted. [Conductors No. 10 AWG and smaller shall be solid copper. Conductors No. 8 AWG and larger shall be stranded copper.] [All conductors shall be copper.] [Conductors No. 6 AWG and smaller shall be copper. Conductors No. 4 AWG and larger shall be either copper or aluminum, at the Contractor's option.] [As an exception, do not substitute aluminum for copper if the equivalent aluminum conductor size would exceed 500 kcmil.]] [Should the Contractor choose to use aluminum for conductors No. 4 AWG and larger, the Contractor shall be responsible for: Increasing the conductor size to have the same ampacity as the copper size indicated; increasing the conduit and pull box sizes to accommodate the larger size aluminum conductors in accordance with NFPA 70; ensuring that the pulling tension rating of the aluminum conductor is sufficient; relocating equipment, modifying equipment terminations, resizing equipment, and resolving to the satisfaction of the Contracting Officer problems that are direct results of the use of aluminum conductors in lieu of 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 3-550-1 for further guidance.

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, shall be 600-volt, [Type THWN/THHN conforming to UL 83] [or] [Type XHHW] [or] [RHW] conforming to UL 44]. Copper conductors shall be annealed copper complying with ASTM B 3 and ASTM B 8. Aluminum conductors shall be Type AA-8000 aluminum conductors complying with ASTM B 800 and ASTM B 801, and shall be of an aluminum alloy listed or labeled by UL as "component aluminum-wire stock (conductor material). Type EC/1350 is not acceptable. Intermixing of copper and aluminum conductors is not permitted.

[2.2.3 Jackets

Multiconductor cables shall have an overall PVC outer jacket.

]2.2.4 Direct Buried

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

2.2.5 In Duct

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

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

2.2.6 Cable Marking

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

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

Conductors shall be color coded. Conductor identification shall be
provided within each enclosure where a tap, splice, or termination is made.

Conductor identification shall be by color-coded insulated conductors,
plastic-coated self-sticking printed markers, colored nylon cable ties and
plates, heat shrink type sleeves, or colored electrical tape. Control
circuit terminations shall be properly identified. Color shall 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 shall
be white with a different colored (not green) stripe for each. Color of
ungrounded conductors in different voltage systems shall be as follows

a. 208/120 volt, three-phase

- (1) Phase A - black
- (2) Phase B - red
- (3) Phase C - blue

b. 480/277 volt, three-phase

- (1) Phase A - brown
- (2) Phase B - orange
- (3) Phase C - yellow

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

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

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Shall provide a uniform compression over the entire conductor contact

surface. Use solderless terminal lugs on stranded conductors.

- a. For use with copper conductors: [UL 486A-486B](#).
- b. For use with aluminum conductors: [UL 486A-486B](#). For connecting aluminum to copper, connectors shall be the circumferentially compressed, metallurgically bonded type.

2.4 LOW VOLTAGE SPLICES

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

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material which shall be 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 shall not require heat or flame, or any additional materials such as covering or adhesive. It shall 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 shall 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 shall not be accepted. 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 and UL 1072] [concentric neutral underground distribution cable conforming to ICEA S-94-649] [metallic armored cables, consisting of three-conductor, multi-conductor cables, with insulation and shielding, as specified, using [a galvanized steel] [an aluminum] interlocked tape armor and thermoplastic jacket]. Provide cables manufactured for use in [duct] [or] [direct burial] applications [as indicated]. Cable shall be rated [5 kV] [15 kV] [25 kV] [28 kV] [35 kV] [as indicated] with [100] [133] percent insulation level.

2.5.2 Conductor Material

NOTE: 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 B 3 and ASTM B 8 for regular concentric and compressed stranding or ASTM B 496 for compact stranding] [aluminum alloy 1350 cables, 3/4 hard minimum complying with ASTM B 609/B 609M and ASTM B 231/B 231M for regular concentric and compressed stranding or ASTM B 400 for compacted stranding].

2.5.3 Insulation

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

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

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

2.5.4 Shielding

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

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

2.5.5 Neutrals

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

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

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

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

2.5.6 Jackets

NOTE: Polyethylene (LLDPE) is exceptional for direct burial and in duct applications where there is significant amounts of water. PVC is acceptable for duct applications. 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.

Cables shall be provided with a [LLDPE][PVC][_____] jacket. Direct buried cables shall be rated for direct burial. Provide type UD cables with an overall jacket.[Provide PVC jackets with a separator that prevents contact when 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: Indoor terminator/outdoor terminations shall be provided 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 Std 48 Class 1.

IEEE Std 48 Class 1; of the molded elastomer, prestretched elastomer, or heat-shrinkable elastomer. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations, where required, shall be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Terminations shall be provided in a kit, including: skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations shall 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 shall 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 shall not require heat or flame for installation. Termination kit shall contain all necessary materials (except for the lugs). Termination shall be designed for installation in low or highly contaminated indoor and outdoor locations and shall resist ultraviolet rays and oxidative decomposition.

2.6.2 Heat Shrinkable Type

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

2.6.3 Separable Insulated Connector Type

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

IEEE Std 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.

- [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 shall 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]. [Grounding elbows][and][feed-thru inserts] shall be delivered to the Contracting Officer.]

2.7 MEDIUM VOLTAGE CABLE JOINTS

Provide joints (splices) in accordance with IEEE Std 404 suitable for the rated voltage, insulation level, insulation type, and construction of the cable. Joints shall be certified by the manufacturer for waterproof, submersible applications. Upon request, supply manufacturer's design qualification test report in accordance with IEEE Std 404. Connectors for joint shall 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 shall be of a cold shrink design that does not require any heat source for its installation. Splice insulation and jacket shall be of a one-piece factory formed cold shrink sleeve made of black EPDM rubber. Splice shall 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

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

]2.10 TAPE

2.10.1 Insulating Tape

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

2.10.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section [31 23 00.00 20 EXCAVATION AND FILL] [31 [_____] .10 [_____]]

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 shall be not less than 0.762 mm .030 inch thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, and shall not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.11 PULL ROPE

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

2.12 GROUNDING AND BONDING

2.12.1 Driven Ground Rods

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

2.12.2 Grounding Conductors

Stranded-bare copper conductors shall conform to [ASTM B 8](#), Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors shall conform to [ASTM B 1](#) for sizes No. 8 and smaller. Insulated conductors shall be of the same material as phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Aluminum is not acceptable.

2.13 CAST-IN-PLACE CONCRETE

NOTE: Use the first bracketed paragraph when project includes a concrete section in Division 3; otherwise, the second bracketed paragraph may be used. Coordinate requirements with Section 03 30 00.00 20, CAST-IN-PLACE CONCRETE for Navy projects and with the appropriate section number in the 03 31 series for Army projects.

Provide concrete in accordance with Section [[03 30 00.00 20](#) CAST-IN-PLACE CONCRETE] [[03 31 \[\]](#) CAST-IN-PLACE CONCRETE] . In addition, provide concrete for encasement of underground ducts with [20 MPa 3000 psi](#) minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts shall be [30 MPa 4000 psi](#) minimum 28-day compressive strength unless specified otherwise.

2.14 UNDERGROUND STRUCTURES

NOTE: Edit this paragraph to comply with project requirements concerning the type of structure or duct, strength of concrete, concrete mix, metal accessories, and excavating and grading. Indicate special reinforcing where required, particularly with duct banks of non-rectangular cross-section. Contact local telephone company, where applicable, concerning the size of all signal manholes and the number and type of signal duct required. Determine availability since aircraft or H2O 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 the Whole Building Design Guide, NAVFAC Specification Graphics:

<http://www.wbdg.org/ccb/NAVGRAPH/UFGS%20and%20NAVFAC%20Graphics%20TOC.pdf>.
Include the required sketches on the project

drawings.

Provide precast concrete underground structures or standard type cast-in-place manhole types as indicated, conforming to ASTM C 857 and ASTM C 478M ASTM C 478. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair strength or appearance. Exposed metal shall 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, shall 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 shall conform to Section [03 30 00.00 20 CAST-IN-PLACE CONCRETE] [03 31 [] 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 shall conform to ASTM C 139 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

In lieu of cast-in-place, Contractors, at their option, may provide precast concrete underground structures subject to the requirements specified below. Precast units shall 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 shall have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures shall have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction shall 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 shall have a 28-day compressive strength of not less than 30 MPa 4000 psi. Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures shall 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 (ϕ) = 0.523 rad 30 degrees
- b. Unit Weight of Soil (Dry) = 1760 kg/m³ 110 pcf, (Saturated)
= 2080 kg/m³ 130 pcf
- c. Coefficient of Lateral Earth Pressure (K_a) = 0.33
- d. Ground Water Level = 915 mm 3 feet below ground elevation

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

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

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

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

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

- e. Vertical design loads shall include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads shall consider all types and magnitudes of vehicular (automotive, industrial, or aircraft) traffic to be encountered. The minimum design vertical load shall be for H20 highway loading per **AASHTO HB-17**.
- f. Horizontal design loads shall 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, shall be considered, along with a pulling-in iron design load of 26,700 N 6000 pounds.
- g. Each structural component shall be designed for the load combination and positioning resulting in the maximum shear and moment for that particular component.
- h. Design shall also consider the live loads induced in the handling, installation, and backfilling of the manholes. Provide lifting devices to ensure structural integrity during handling and installation.

2.14.2.3 Construction

Structure top, bottom, and wall shall be of a uniform thickness of not less than 150 mm 6 inches. Thin-walled knock-out panels for designed or future duct bank entrances shall not be permitted. Quantity, size, and location of duct bank entrance windows shall be as directed, and cast completely open by the precaster. Size of windows shall exceed the nominal duct bank envelope dimensions by at least 305 mm 12 inches vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows shall be a minimum of 150 mm 6 inches from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. Provide drain sumps a minimum of 305 mm 12 inches in diameter and 100 mm 4 inches deep for precast structures.

2.14.2.4 Joints

Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to AASHTO M 198, Type B. 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

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

[2.14.5 Frames and Covers for Airfield Facilities

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

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

surface. Steel frames and covers shall be hot dipped galvanized after fabrication.

] 2.14.6 Ductile Iron Frames and Covers for Airfield Facilities

NOTE: As an option, the designer may also allow the
use of this paragraph for structures subject to
aircraft loading.

At the contractor's option, ductile iron covers and frames designed for a minimum proof load of 100,000 pounds 45,000 kg, may be provided in lieu of the steel frames and covers indicated. Covers shall be of the same material as the frames (i.e. ductile iron frame with ductile iron cover, galvanized steel frame with galvanized steel cover). Proof loading shall be performed in accordance with CID A-A-60005 and ASTM A 48/A 48M. Proof loads shall 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. The top of the structure shall be modified to accept the ductile iron structure in lieu of the steel structure indicated. The finished structure shall be level and non-rocking, with the top flush with the surrounding pavement.

] 2.14.7 Brick for Manhole Collar

NOTE: Do not use brick for manholes in Iceland.

Brick shall be sewer and manhole brick conforming to ASTM C 32, Grade MS.

2.14.8 Composite/Fiberglass Handholes and Covers

Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass.

2.15 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

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

2.15.1 Cable Racks

The wall bracket shall be 100 mm 4 inches by approximately 38 mm by 4.76 mm 1-1/2 inch by 3/16 inch channel steel, 1220 mm 48 inches long (minimum) in manholes. Slots for mounting cable rack arms shall be spaced at 200 mm 8 inch intervals.

2.15.2 Rack Arms

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

2.15.3 Insulators

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

2.16 CABLE TAGS IN MANHOLES

**NOTE: Verify cable labeling requirements with the
local Activity.**

Provide tags for each power cable located in manholes. The tags shall be polyethylene. Do not provide handwritten letters. The first position on the power cable tag shall denote the voltage. The second through sixth positions on the tag shall identify the circuit. The next to last position shall denote the phase of the circuit and shall include the Greek "phi" symbol. The last position shall denote the cable size. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

2.16.1 Polyethylene Cable Tags

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

2.17 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 shall be hook-stick operable, deadfront construction conforming to the requirements of IEEE C37.20.3, Category A. Cabinets shall be provided with [with 200 A. loadbreak junctions and elbow-type separable loadbreak connectors, cable parking stands, and grounding lugs] [with 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 Std 386.

Ratings at 60 Hz shall be:

Nominal voltage (kV).....[_____]

Rated maximum voltage (kV).....[[15] [25] [35]]

Rated continuous current (A).....[[200][600]]

Three-second short-time current-carrying capacity (kA).....[_____]

BIL (kV).....[_____]

2.18 PROTECTIVE DEVICES AND COORDINATION

NOTE: Do not use on Navy Projects.

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. The protective devices should be selected and specified 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 Std 242, and IEEE Std 141. The designer shall either utilize UFGS 26 28 01.00 10 or incorporate protective device requirements in this specification.

Provide protective devices and coordination as specified in Section
26 28 01.00 10

2.19 SOURCE QUALITY CONTROL

2.19.1 Arc-Proofing Test for Cable Fireproofing Tape

Manufacturer shall test one sample assembly consisting of a straight lead tube 305 mm 12 inches long with a 65.5 mm 2 1/2 inch outside diameter, and a 3.175-mm 1/8 inch thick wall, and covered with one-half lap layer of arc and fireproofing material per manufacturer's instructions. The arc and fireproofing tape shall 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 shall be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. The arc shall be directed toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Each sample assembly shall be tested at three unrelated points. Start time for tests shall 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 shall 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 shall indicate that the test has been performed and passed by the manufacturer.

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

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

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

3.2 CABLE INSPECTION

Prior to installation, each cable reel shall be inspected for correct storage positions, signs of physical damage, and broken end seals. If end seal is broken, moisture shall be removed 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.

The Contractor shall 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. The Contractor shall then [prepare a checklist of significant requirements] [perform pulling calculations and prepare a pulling plan] which shall be submitted along with the manufacturers instructions in accordance with SUBMITTALS. Cable shall be installed strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

[Calculations and pulling plan shall include:

- a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.
- b. List of cable installation equipment.
- c. Lubricant manufacturer's application instructions.
- d. Procedure for resealing cable ends to prevent moisture from entering cable.
- e. Cable pulling tension calculations of all cable pulls.
- f. Cable percentage conduit fill.
- g. Cable sidewall bearing pressure.
- h. Cable minimum bend radius and minimum diameter of pulling wheels used.
- i. Cable jam ratio.
- j. Maximum allowable pulling tension on each different type and size of conductor.
- k. Maximum allowable pulling tension on pulling device.

] 3.4 UNDERGROUND FEEDERS SUPPLYING BUILDINGS

NOTE: For Navy only, choose PVC.

Terminate underground feeders supplying building at a point 1525 mm 5 feet outside the building and projections thereof, except that conductors shall 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. Conduit shall be [PVC, Type EPC-40] [IMC] [RGS] from the supply equipment to a point 1525 mm 5 feet outside the building and projections thereof. Protect ends of underground conduit with plastic plugs until connections are made.

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

3.5 UNDERGROUND STRUCTURE CONSTRUCTION

NOTE: Edit this paragraph to comply with project requirements concerning the type of structure, strength of concrete, concrete mix, metal accessories, and excavating and grading. Indicate special reinforcing where required. Contact local telephone company, where applicable, concerning the size of all signal manholes and the number and type of signal duct required. Determine availability since H2O 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 shall 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 shall conform to [ASTM C 309](#). 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 shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair strength or appearance. Exposed metal shall 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.

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 C 139](#) and Section [04 20 00 MASONRY](#)] [Concrete block is not allowed in areas subject to aircraft loading.]

3.5.2 Precast Concrete Construction

Set commercial precast structures on [150 mm 6 inches](#) of level, 90 percent compacted granular fill, [19 mm to 25 mm 3/4 inch to 1 inch](#) size, extending [305 mm 12 inches](#) beyond the structure on each side. Compact granular fill by a minimum of four passes with a plate type vibrator. Installation shall 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 shall be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor the irons shall be a minimum of [150 mm 6 inches](#) from the edge of the sump, and in the walls the irons shall be

located within 150 mm 6 inches of the projected center of the duct bank pattern or precast window in the opposite wall. However, the pulling-in iron shall not be located within 150 mm 6 inches of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 150 mm 6 inch clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 915 mm 3 foot length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner shall be positioned directly in line with, or when not possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of 75 mm 3 inches from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons shall have a clear projection into the structure of approximately 100 mm 4 inches and shall be designed to withstand a minimum pulling-in load of 26,700 N 6000 pounds. Irons shall be hot-dipped galvanized after fabrication.

3.5.4 Cable Racks, Arms and Insulators

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

- a. Provide a 15 mm diameter by 125 mm 5/8 inch diameter by 5 inch long anchor bolt with 75 mm 3 inch foot cast in structure wall with 50 mm 2 inch protrusion of threaded portion of bolt into structure. Provide 15 mm 5/8 inch steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.
- b. Provide concrete channel insert with a minimum load rating of 1192 kg per meter 800 pounds per foot. Insert channel shall be steel of the same length as "vertical rack channel;" channel insert shall be cast flush in structure wall. Provide 15 mm 5/8 inch steel nuts in channel insert to receive 15 mm diameter by 75 mm 5/8 inch diameter by 3 inch long steel, square head anchor bolts.
- c. Provide concrete "spot insert" at each anchor bolt location, cast flush in structure wall. Each insert shall have minimum 365 kg 800 pound load rating. Provide 15 mm diameter by 75 mm 5/8 inch diameter by 3 inch long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing bolts.

3.5.5 Field Painting

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

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

3.6 DIRECT BURIAL CABLE SYSTEM

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

3.6.1 Trenching

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

3.6.2 Cable Installation.

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

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

Where two or more cables are laid parallel in the same trench, space cables laterally at not less than 75 mm 3 inches apart, except that communication cable shall be separated from power cable by a minimum distance of 305 mm 12 inches.

Where direct-burial cables cross under roads or other paving exceeding 1.5 m 5 feet in width, such cables shall be installed in [concrete-encased] ducts. Where direct-burial cables cross under railroad tracks, such cables shall be installed in [reinforced concrete-encased ducts] [ducts installed through rigid galvanized steel sleeves]. Ducts shall extend at least 300 mm 1 foot beyond each edge of any paving and at least 1.5 m 5 feet beyond each side of any railroad tracks. Cables may be pulled into duct from a fixed reel where suitable rollers are provided in the trench. Where direct burial cable transitions to duct-enclosed cable, direct-burial cables shall be centered in duct entrances, and a waterproof nonhardening mastic compound shall be used to facilitate such centering. If paving or railroad tracks are in place where cables are to be installed, coated rigid steel conduits driven under the paving or railroad tracks may be used in lieu of concrete-encased ducts. Damage to conduit coatings shall be prevented by

providing ferrous pipe jackets or by predrilling. Where cuts are made in any paving, the paving and subbase shall be restored to their original condition. Where cable is placed in duct(e.g. under paved areas, roads, or railroads), slope ducts to drain.

3.6.3 Splicing

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

Provide cables in one piece without splices between connections except where the distance exceeds the lengths in which cables are manufactured. [Where splices are required, provide splices designed and rated for direct burial.]

3.6.4 Bends

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

3.6.5 Horizontal Slack

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

3.6.6 Identification Slabs [Markers]

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

3.7 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.7.1 Requirements

NOTE: Specify cover requirements in accordance with NFPA 70 and IEEE C2. Indicate direct buried conduit and concrete encased conduit on drawings. Ensure that duct is specified to be installed below the frost line depth.

Depths to top of the conduit shall be in accordance with NFPA 70. Run conduit in straight lines except where a change of direction is necessary. Numbers and sizes of ducts shall be as indicated. Ducts shall have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 100 mm per 30 m. [3] [4] inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius shall be 450 mm (18 inches) 18 inches for ducts of less than 80 mm (3 inch) 3 inch diameter, and 900 mm (36 inches) 36 inches for ducts 80 mm (3 inches) 3 inches or greater in diameter. Otherwise, long sweep bends having a minimum radius of 7.6 m 25 feet shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells whenever duct lines terminate in structures.

3.7.2 Treatment

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

3.7.3 Conduit Cleaning

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

3.7.4 Jacking and Drilling Under Roads and Structures

Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, shall be zinc-coated, rigid steel, jacked into place. Where ducts are jacked under existing pavement,

rigid steel conduit will be installed because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 15 m 50 feet in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks shall be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 1.2 m 4 feet on centers. [Hydraulic jet method shall not be used.]

3.7.5 Galvanized Conduit Concrete Penetrations

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

3.7.6 Multiple Conduits

Separate multiple conduits by a minimum distance of 65 mm 2 1/2 inches, except that light and power conduits shall be separated from control, signal, and telephone conduits by a minimum distance of [75] [300] mm [3] [12] inches. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly shall consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 3050 mm 10 feet of conduit assembly.

3.7.7 Conduit Plugs and Pull Rope

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

3.7.8 Conduit and Duct Without Concrete Encasement

Provide not less than 75 mm 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 75 mm 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 6.25 mm 1/4 inch sieve. The first 150 mm 6 inch layer of backfill cover shall be sand compacted as previously specified. The rest of the excavation shall be backfilled and compacted in 75 to 150 mm 3 to 6 inch layers. Provide color, type and depth of warning tape as specified in Section [31 23 00.00 20 EXCAVATION AND FILL] [31 00 00 EARTHWORK].

3.7.8.1 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 75 mm 3 inch concrete cover around ducts. Concrete encasement shall extend at least 1525 mm 5 feet beyond the edges of paved areas and roads, and 3660 mm 12 feet beyond the rails on each side of railroad tracks.

3.7.9 Duct Encased in Concrete

NOTE: Edit this paragraph to comply with project requirements concerning type of structure or duct, strength of concrete, concrete mix, metal accessories, and excavating and grading. Indicate special reinforcing where required, particularly with duct banks of non-rectangular cross-section. Separation of ducts from each other (65 mm (2 1/2 inches) may be specified in accordance with calculations from NFPA 70. Separation can be reduced for telecommunication ducts since heat gain is not a factor.

Medium voltage cables and campus distribution cables of telecommunications backbone distribution system shall 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.

Construct underground duct lines of individual conduits encased in concrete. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank shall be rectangular in cross-section and shall provide at least 75 mm 3 inches of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 65 mm 2 1/2 inches, except separate light and power conduits from control, signal, and telecommunications conduits by a minimum concrete thickness of 75 mm 3 inches. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring shall be done by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly. [Provide color, type and depth of warning tape as specified in Section [31 00 00 EARTHWORK] [31 23 00.00 20 EXCAVATION AND BACKFILL.]]

3.7.9.1 Connections to Manholes

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

3.7.9.2 Connections to Existing Underground Structures

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

3.7.9.3 Connections to Existing Concrete Pads

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

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

3.7.9.4 Connections to Existing Ducts

Where connections to existing duct banks are indicated, excavate the banks to the maximum depth necessary. Cut off the banks and remove loose concrete from the conduits before new concrete-encased ducts are installed.

Provide a reinforced concrete collar, poured monolithically with the new duct bank, to take the shear at the joint of the duct banks. [Remove existing cables which constitute interference with the work.] [Abandon in place those no longer used ducts and cables which do not interfere with the work.]

3.7.9.5 Partially Completed Duct Banks

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

[3.7.9.6 Removal of Ducts

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

]3.8 CABLE PULLING

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

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

the grip before splicing and terminating.

3.8.1 Cable Lubricants

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

3.9 CABLES IN UNDERGROUND STRUCTURES

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

3.9.1 Cable Tag Installation

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

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

3.10 CONDUCTORS INSTALLED IN PARALLEL

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

3.11 LOW VOLTAGE CABLE SPLICING AND TERMINATING

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

[3.11.1 Terminating Aluminum Conductors

- a. Use particular care in making up joints and terminations. Remove surface oxides by cleaning with a wire brush or emery cloth. Apply joint compound to conductors, and use UL-listed solid aluminum connectors for connecting aluminum conductors. When connecting aluminum to copper conductors, use connectors specifically designed for this purpose.
- b. Terminate aluminum conductors to copper bus either by: (1) in

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

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

] 3.12 MEDIUM VOLTAGE CABLE TERMINATIONS

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

3.13 MEDIUM VOLTAGE CABLE JOINTS

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

3.13.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice.

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

3.14 CABLE END CAPS

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

[3.15 LIVE END CAPS

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

]3.16 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

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

3.16.1 Fireproofing Tape

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

[3.16.2 Tape-Wrap

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

]3.17 GROUNDING SYSTEMS

Provide grounding system as indicated, in accordance with NFPA 70 and IEEE C2, and as specified herein.

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

Noncurrent-carrying metallic parts associated with electrical equipment shall have a maximum resistance to solid earth ground not exceeding the following values:

Pad-mounted transformers without protective fences	5 ohms
Ground in manholes	5 ohms
Grounding other metal enclosures of primary voltage electrical and electrically-operated equipment	5 ohms

3.17.1 Grounding Electrodes

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

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

3.17.2 Grounding Connections

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

- a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.
- b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

3.17.3 Grounding Conductors

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

3.17.4 Ground Cable Crossing Expansion Joints

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

3.17.5 Manhole Grounding

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

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

shields, metal cable racks, and other metal equipment with a minimum 6 AWG conductor.

[3.17.6 Fence Grounding

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

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

]3.18 EXCAVATING, BACKFILLING, AND COMPACTING

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

3.18.1 Reconditioning of Surfaces

3.18.1.1 Unpaved Surfaces

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

3.18.1.2 Paving Repairs

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

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

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists [,

restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.] [Make repairs as specified in Section [32 13 13.06 PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES] [____].]

3.19 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section .[03 30 00.00 20 CAST-IN-PLACE CONCRETE] [03 31 [____] CAST-IN-PLACE CONCRETE [...]]

3.19.1 Concrete Slabs for Equipment

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

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

[3.19.2 Sealing

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

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

]3.20 FIELD QUALITY CONTROL

3.20.1 Performance of Field Acceptance Checks and Tests

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

3.20.1.1 Medium Voltage Cables

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

a. Visual and Mechanical Inspection

- (1) Inspect exposed cable sections for physical damage.
- (2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

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

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

(5) Inspect for proper fireproofing.

(6) Visually inspect jacket and insulation condition.

(7) Inspect for proper phase identification and arrangement.

b. Electrical Tests

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

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

CABLE RATING AC TEST VOLTAGE for ACCEPTANCE TESTING

5 kV	10kV rms (peak)
8 kV	13kV rms (peak)
15 kV	20kV rms (peak)
25 kV	31kV rms (peak)
35 kV	44kV rms (peak)

CABLE RATING AC TEST VOLTAGE for MAINTENANCE TESTING

5 kV	7kV rms (peak)
8 kV	10kV rms (peak)
15 kV	16kV rms (peak)
25 kV	23kV rms (peak)
35 kV	33kV rms (peak)

3.20.1.2 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 Std 81**. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use

a portable megohmmeter tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

3.20.2 Follow-Up Verification

Upon completion of acceptance checks and tests, the Contractor shall 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 shall be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --