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NAVFAC **IGS-16303 (OCTOBER 2002)**

Preparing Activity: LANTNAVFACENGCOM **Based on NFGS-L-16303**

ITALIAN GUIDE SPECIFICATIONS

Use for ITALIAN projects only

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SECTION 16303

UNDERGROUND ELECTRICAL WORK

10/02

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NOTE: This guide specification is issued by the Atlantic Division, Naval Facilities Engineering Command for regional use in Italy.

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NOTE: This guide specification covers underground electrical work, basic to underground electrical and telecommunication distribution systems.

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NOTE: The following information should be shown on the drawings.

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

b. Location of manholes, handholes, ducts, and cables.

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

d. Do not include sketches in project specifications. Use underground sketches as details on drawings whenever possible. If special features are required for a project, do not revise sketches, but indicate these changes as notes below the detail. Sketch numbers and dates should remain on the drawing details.

e. Circuit identification.

f. Special conditions.

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Comments and suggestion on this 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.

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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PART 1 GENERAL

1.1 REFERENCES

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

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NOTE: The following reference is included for design information only.

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

FAA AC-150/5320-6 (1995; Rev. D) Airport Pavement Design and Evaluation

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AMERICAN CONCRETE INSTITUTE (ACI)

ACI 318M/318RM	(1999) Building Code Requirements for Reinforced Concrete (ACI 318M-99) and Commentary (ACI 318RM-99)

EUROPEAN COMMUNITY QUALITY MARKS (CE)

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NOTE: CE (European Community) is a European quality marking system indicating that the equipment or product conforms to EEC (European Economic Community) standards concerning quality of safety and health and conforms with all the Italian technical standards in force. All products (Electrical, Mechanical and Electronic Equipment and similar items) that are marked CE conform to the standards and Laws enforced in Europe. In Italy, the CE marking is a mandatory requirement and must be shown on all applicable equipment and products attesting to the conformity

with the EEC standards.

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CE European Quality Mark

ITALIAN ELECTROTECHNICAL COMMITTEE STANDARDS (CEI)

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NOTE: A CEI Norm is an Italian technical normative for electrical systems recognized by Italian Law, submitted by a private organization "Comitato Electrotecnico Italiano" for the Italian territory, available in the Italian language and only in some cases in English.

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CEI 7-1	(1997) Copper and copper alloy conductors for overhead lines
CEI 11-1	(1999; V1 2000) Power installations exceeding 1 kV a.c.
CEI 11-17	(1997) Generation, transmission and distribution systems of electric power - Cables installations
CEI 20-1	(1998) Paper-insulated cables for electrical systems with rated voltages between 1 kV and 45 kV
CEI 20-13	(1999; V1 2001, V2 2001) Rubber insulated cables with rated voltages between 1 kV and 30 kV
CEI 20-20/1	(2000) Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V - Part 1: General requirements
CEI 20-22/2	(1999; V1 2001) Tests on electric cables under fire conditions. Part 2: Fire propagation
CEI 20-24	(1998) Joints and terminals for power cables
CEI 20-28	(1998) Connectors for power cables
CEI 20-33	(1998) Joints and terminals for cables with voltage Uo/U not exceeding 600/1000 V a.c. and 750 V d.c.
CEI 64-8	(1998; V1 2001, V2 2001) Electrical installations of buildings

ITALIAN ELECTOTECHNICAL COMMITTEE TABLES (CEI UNEL)

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NOTE: A CEI UNEL is an Italian electrical technical data base describing characteristics, dimensions and sizes of the electrical equipment in compliance with CEI Norms recognized by the Italian Law for the Italian territory.

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CEI-UNEL 35375	(2001) Fire retardant power cables, HEPR insulated PVC sheathed, with reduced emission of corrosive gases - Single and multicore cables with flexible conductors for fixed installations - Rated voltage Uo/U: 0,6/1 kV

ITALIAN LAWS AND NORMS (D.M.)(LAW)(CIRC.)

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NOTE: Italian laws and normatives are the legislative regulations and decrees issued by the Italian government in the form of laws, norms, decrees, circulars, and letters. These Laws and Decrees concur together with Norms and Standards in forming the governing directives for construction.

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Law 1086	(November 5, 1971) Norms for the discipline of normal and prestressed reinforced concrete structures and metal structures
D.M. 9-1-96	(1996) Technical norms for the calculations, executions and testing of normal and prestressed reinforced concrete structures, and metal structures
D.M. 16-1-96	(1996) Technical norms relative to general criteria for building safety verification and for loads and superimposed loads

ITALIAN NATIONAL ASSOCIATION FOR UNIFICATION OF STANDARDS (UNI)

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NOTE: A UNI Norm is a technical normative recognized as Italian Law, submitted by a private organization "Ente Nazionale Italiano di Unificazione" for Italy and is available only in the Italian language. It is the National Standard.

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UNI 6125	(1974) Pipe threads for cable conduits and

	screwed fittings for explosion proof electrical plants
UNI 7683	(1977) Threaded tubes and fittings for cable conduits for explosion proof electrical installations - Unalloyed steel seamless and welded tubes, galvanized
UNI 8656	(1984) Liquid membrane-forming compounds for the protection of the concrete during the maturation - Classification and requirements
UNI 8863	(1987) Unalloyed steel seamless and welded tubes suitable for screwing in accordance with UNI ISO 7/1

ITALIAN/EUROPEAN HARMONIZATION STANDARDS (UNI EN)(UNI ENV)(CEI EN) (UNI EN ISO)(UNI ISO)

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NOTE: A UNI EN, UNI ENV, CEI EN, UNI EN ISO or UNI ISO is a European Standard with a coincident Italian National Standard or International Standard. The two standards are identical, with most (but not all) EN's available in the English language and the UNI available only in the Italian language.

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UNI EN 124	(1995) Gully tops and manhole tops for vehicular and pedestrian areas - Design requirements, type testing, marking, quality control
CEI EN 50086-1	(1997) Conduit systems for electrical installations - Part 1: General requirements
CEI EN 50086-2-1	(1996; A11 1999) Conduit systems for electrical installations - Part 2-1: Particular requirements for rigid conduit systems
CEI EN 50086-2-4	(1997; A1 2001) Conduit systems for electrical installations - Part 2-4: Particular requirements for conduit systems buried underground
CEI EN 60454-1	(1997) Specifications for pressure-sensitive adhesive tapes for electrical purposes - Part 1: General requirements

CEI EN 60454-3-2	(1999) Pressure-sensitive adhesive tapes for electrical purposes - Part 3: Specifications for individual materials - Sheet 2: Polyester film tapes with rubber thermosetting or acrylic crosslinked adhesives
CEI EN 60529	(1997; A1 2000) Degrees of protection provided by enclosures (IP Code)
CEI EN 60811-1-1	(2001) Insulating and sheathing materials of electric cables - Part 1: General application - Section 1: Measurement of thickness and overall dimension - Test for determining the mechanical properties

1.2 RELATED REQUIREMENTS

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NOTE: Specification Section 16081, "Apparatus Inspection and Testing" applies only when medium voltage cable, medium voltage cable splices or medium voltage terminations are included in the project.

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Section 16050, "Basic Electrical Materials and Methods" and Section 16081, "Apparatus Inspection and Testing" apply to this section with additions and modifications specified herein.

1.2.1 Underground Service

Terminate underground service into building at a point 1525 mm outside the building and projections thereof, except that service conductors shall be continuous to the interior terminating point indicated. Connections of the service to the service entrance equipment is included in Section 16402, "Interior Distribution System." Protect ends of underground conduit with threaded metal caps or plastic plugs as applicable until connections are made.

1.3 DEFINITIONS

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

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

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NOTE: Areas subject to aircraft loading are generally defined as follows:

1. For fixed wing aircraft facilities:

a) On or within 61 m of runway sideline
b) On or within 15 m of taxiway or apron sideline
c) Within Type 1 clear zone area as defined by 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.

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

1.4 SUBMITTALS

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NOTE: Where a "G" in asterisk tokens follows a submittal item, it indicates Government approval for that item. Add "G" in asterisk tokens following any added or existing submittal items deemed sufficiently critical, complex, or aesthetically significant to merit approval by the Government. Submittal items not designated with a "G" will be approved by the CQC organization.
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Submit the following in accordance with the Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Precast underground structures; G

Pulling-in irons; G

SD-03 Product Data

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

Medium voltage cable; G

Medium voltage cable terminations; G

Medium voltage cable joints; G

[Live end caps; G]

Precast concrete structures; G

Sealing material for precast manhole and handhole joints; G

Manhole frames and covers; G

Handhole frames and covers; G

[Frames and covers for airfield facilities; G]

Polypropylene handholes; G

Cable supports (racks, arms and insulators); G

SD-06 Test Reports

Arc-proofing test for cable fireproofing materials; G

Medium voltage cable qualification and production tests; G

Field Acceptance Checks and Tests; G

Identify each cable for 600-volt, and medium voltage cable tests. When testing grounding electrodes and grounding systems, identify each grounding electrode and each grounding system for testing. Include the test method and test setup (i.e. pin locations) used to determine ground resistance and soil conditions at the time the measurements were made.

SD-07 Certificates

Cable splicer/terminator; G

1.5 QUALITY ASSURANCE

1.5.1 Precast Underground Structures

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

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

b. Manufacturer's printed assembly and installation instructions

c. Design calculations

d. Reinforcing shop drawings prepared in accordance with Law 1086

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

1.5.2 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.

PART 2 PRODUCTS

2.1 SOURCE MANUFACTURERS

2.1.1 Rigid Metal Conduit

The following manufacturers provide rigid metal conduit materials that generally comply with these specifications:

DALMINE
Piazza Caduti 6 Luglio 1944, 1
24044 Dalmine (BG)
Tel: 035/560111
Fax: 035/565768

PESSINA TUBI S.p.A.
20099 Sesto San Giovanni (MI)
via D. Manin 101
Tel: 39-022-401306
Fax: 39-022-6223031

2.1.2 Metal Fittings

The following manufacturers provide metal fittings for electrical conduit that generally complies with these specifications:

JANNONE FERRO TUBI
Via Miglio, 10/12 - 20090 Segrate Milano
Tel: 02-26921377
Fax: 02-2135559

FERROTUBI e DERIVATI

Via G. Rossa, 1
20061 Carugate (MI)
Tel: 39-292-15090019
Fax: 39-292-150391

2.1.3 Plastic Conduit

The following manufacturers provide plastic conduit materials that generally comply with these specifications:

DIELECTRIX ITALIA
Via E. Pavese, 53
29015 Castel San Giovanni (PC)
Tel: 0523/882241
Fax: 0523/881270

RICCINI S.r.l.
06077 Ponte Felcino (PG)
Str. Tiberina Nord 28/A
Tel: 075-5917010
Fax: 075-9517020
www.riccini.it

2.1.4 Plastic Fittings

The following manufacturers provide plastic fittings for electrical conduit that generally complies with these specifications:

DIELECTRIX ITALIA
Via E. Pavese, 53
29015 Castel San Giovanni (PC)
Tel: 0523/882241
Fax: 0523/881270

EMP
Via Eridania 187
Occhiobello (RO)
Tel: 0425-750780
Fax: 0425-750607

2.1.5 Plastic Duct

The following manufacturers provide that generally comply with these specifications:

DIELECTRIX ITALIA
Via E. Pavese, 53
29015 Castel San Giovanni (PC)
Tel: 0523/882241
Fax: 0523/881270

RICCINI S.r.l.
06077 Ponte Felcino (PG)
Str. Tiberina Nord 28/A

Tel: 075-5917010
Fax: 075-9517020
www.riccini.it

2.1.6 Plastic Duct Fittings

The following manufacturers provide plastic fittings for electrical duct that generally complies with these specifications:

DIELECTRIX ITALIA
Via E. Pavese, 53
29015 Castel San Giovanni (PC)
Tel: 0523/882241
Fax: 0523/881270

PM PLASTIC MATERIALS
24031 Almenno S. Salvatore (BG)
Via Gari Baldi, 44
Tel: 035-640027
Fax: 035-640741

2.1.7 600 Volt Conductor

The following manufacturers provide 600 volt conductor wiring that generally complies with these specifications:

PIRELLI
Viale Sarca, 222
20126 Milano
Tel: 02/6442.1
Fax: 02/6442.9264
E-mail: cables-it.gw@pirelli.com
Web Site: www.it.pirelli.com/cables

CEATCAVI
L.go Regio Parco, 9
10152 Torino
Tel: 011/26081
Fax: 011/858265
Telex: 221603 CEATI

NEXANS
20059 Vimercate (MI)
Via Trento, 30
Tel: 039-6861
Fax: 039-6869049
Web Site: www.nexans.com

2.1.8 600 Volt Wire Connectors & Terminals

The following manufacturers provide that generally comply with these specifications:

GESTRA S.r.l.

Via Ippolito Nievo, 61
00153 Roma
Tel: 06/5803523
Fax: 06/5816348
E-mail: gestra@tin.it

NEXANS
20059 Vimercate (MI)
Via Trento, 30
Tel: 039-6861
Fax: 039-6869049
Web Site: www.nexans.com

2.1.9 Medium Voltage Cable (EPR)

The following manufacturers provide EPR medium voltage cable materials that generally comply with these specifications:

PIRELLI
Viale Sarca, 222
20126 Milano
Tel: 02/6442.1
Fax: 02/6442.9264
E-mail: cables-it.gw@pirelli.com
Web Site: www.it.pirelli.com/cables

ARISTONCAVI
Via Einaudi, 42/44
36040 Brendola (VI)
Tel: 0444/492288
Fax: 0444/492094
Web Site: www.aristoncavi.com
E-mail: salesAristoncavi@aristoncavi.com

NEXANS
20059 Vimercate (MI)
Via Trento, 30
Tel: 039-6861
Fax: 039-6869049
Web Site: www.nexans.com

2.1.10 Medium Voltage Cable (Paper)

The following manufacturers provide paper medium voltage cable materials that generally comply with these specifications:

PIRELLI
Viale Sarca, 222
20126 Milano
Tel: 02/6442.1
Fax: 02/6442.9264
E-mail: cables-it.gw@pirelli.com
Web Site: www.it.pirelli.com/cables

CEATCAVI
L.go Regio Parco, 9
10152 Torino
Tel: 011/26081
Fax: 011/858265
Telex: 221603 CEATI

2.1.11 Medium Voltage Cable Termination & Joints

The following manufacturers provide medium voltage cable terminations and joints that generally comply with these specifications:

PIRELLI
Viale Sarca, 222
20126 Milano
Tel: 02/6442.1
Fax: 02/6442.9264
E-mail: cables-it.gw@pirelli.com
Web Site: www.it.pirelli.com/cables

NEXANS
20059 Vimercate (MI)
Via Trento, 30
Tel: 039-6861
Fax: 039-6869049
Web Site: www.nexans.com

3M Italia
20090, Segrate (MI)
Via S. Bovio, 3
Web Site: www.psie.it

2.1.12 Insulating Tape

The following manufacturers provide insulating tape materials that generally comply with these specifications:

DIELETTRICA LIGURE S.r.l.
16039 Sestri Levante (GE)
Tel: 0185/43095
Fax: 0185/456966

FACOT CHEMICALS
Via Crema, 44
26010 Capralba (CR)
Tel: 0373/450642 - 450643
Fax: 0373/450751

3M Italia
20090, Segrate (MI)
Via S. Bovio, 3
Web Site: www.psie.it

2.1.13 Fireproofing Tape

The following manufacturers provide fireproofing tape materials that generally comply with these specifications:

NEXANS
20059 Vimercate (MI)
Via Trento, 30
Tel: 039-6861
Fax: 039-6869049
Web Site: www.nexans.com

RAYTECH
20019 Settimo
Milanese (MI)
Via Pordoi, 8
Tel: 02-33500147
Fax: 02-33500287

2.1.14 Grounding Pit and Rods

The following manufacturers provide grounding pit and rod materials that generally comply with these specifications:

CARPANETO
Via Ferrero, 10
10090 Cascine Vica - Rivoli (TO)
Tel: 011/9590111
Fax: 011/9590200
Web Site: www.carpaneto.it

FURSE - GESTRA S.r.l.
Via Ippolito Nievo, 61
00153 Roma
Tel: 06/5803523
Fax: 06/5816348
E-mail: gestra@tin.it

2.1.15 Grounding Connectors

The following manufacturers provide grounding connectors and exothermic weld materials that generally comply with these specifications:

ELETTROTECNICA ADRIATICA S.r.l.
Via Pineta Formica n. 13
48015 Cervia (RA)
Tel: 0544-971729
Fax: 0544-972040
E-mail: mail@elettrotecnicaadriatica.it
www.eleettrotecnicaadriatica.it

ERICO ITALIA S.r.l.
15, v. M. Buonarroti
20090 Cesano Boscone (MI)
Tel: 02-45866517

Fax: 02-48600622
E-mail: ericoitalia@erico.com

2.1.16 Precast Concrete Manhole

The following manufacturers provide precast concrete manholes that generally comply with these specifications:

PREFABBRICATI LUCCHESE
Via S. Marco, 55
31031 Caerano di S. Marco (TV)
Tel: 0423/650041
Fax: 0423/859182

MUSILLI PREFABBRICATI
Via Casilina Sud, 49
03043 Cassino (FR)
Tel: 0776/312431
Fax: 0776/310420

2.1.17 Manhole/Handhole Frames and Covers

The following manufacturers provide manhole and handhole frames and covers that generally comply with these specifications:

TUBI GHISA
Via E. Romagnoli, 6
20146 Milano
Tel: 02/42431

RICCINI
Strada Tiberina Nord, 28/A
Località Ponte Felcino
I-06077 Perugia
Tel: 075/5917010
Fax: 075/5917020
E-mail: info@riccini.it

2.1.18 Fiberglass Handholes

The following manufacturers provide fiberglass handholes that generally comply with these specifications:

RICCINI
Strada Tiberina Nord, 28/A
Località Ponte Felcino
I-06077 Perugia
Tel: 075/5917010
Fax: 075/5917020
E-mail: info@riccini.it

DIELECTRIX ITALIA
Via E. Pavese, 53
29015 Castel San Giovanni (PC)

Tel: 0523/882241
Fax: 0523/881270

2.1.19 Cable Supports

The following manufacturers provide cable supports that generally comply with these specifications:

CLAMPCO SISTIMI
Via Aquileia Area PIP
34076 Romans
D'Isonzo - Gorizia
Tel: 0481-909171
Fax: 0481-909230

GRUPPO CARPANETO SATI
Via Enrico Schliemann, 11 - 00178 Roma
Tel: 06-7235606, 06-72670250
Fax: 06-72670256

2.2 MATERIALS AND EQUIPMENT

2.2.1 Conduit

2.2.1.1 Rigid Metal Conduit

UNI 6125, UNI 8863, UNI 7683, galvanized steel, threaded type.

2.2.1.2 Plastic Conduit for Direct Burial

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NOTE: Refer to CEI EN 50086-1 for PVC for general underground direct burial use.
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CEI EN 50086-1 and CEI EN 50086-2-4, heavy duty type.

2.2.1.3 Plastic Utilities Duct for Concrete Encasement

CEI EN 50086-1 and CEI EN 50086-2-1, medium duty type.

2.2.2 Fittings

2.2.2.1 Metal Fittings

UNI 6125, threaded type.

2.2.2.2 PVC Conduit Fittings

CEI EN 50086-1 and CEI EN 50086-2-1.

2.2.2.3 PVC Duct Fittings

CEI EN 50086-1 and CEI EN 50086-2-1.

2.2.2.4 Innerduct

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

[2.2.2.5 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 CEI EN 60529.

]2.2.3 Conductors Rated 600 Volts and Less

Conductor sizes are designated in square millimeters. 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.

2.2.3.1 Conductor Types and Color Coding

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NOTE: Use only ethylene propylene rubber insulated cables (EPR). Ensure that the conduit has been properly sized for the number of EPR cables indicated in each conduit run.
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Direct buried conductors shall conform to CEI 20-13, and CEI-UNEL 35375, Type G7. Conductors in conduit shall conform to CEI 20-13, and CEI-UNEL 35375, Type EPR, and CEI 20-22/2. Conductor size and number of conductors in each cable shall be as indicated. 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, or heat shrink type sleeves. Control circuit terminations shall be properly identified. Conductors 6 mm^2 and smaller shall be solid copper. Conductors 10 mm^2 and larger shall be stranded copper. All conductors shall be copper.

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NOTE: Coordinate color code with installation where project is located. Revise this paragraph as necessary. When activity does not have a color coding standard or does not have a preference, select the unbracketed colors.
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a. Colors for coding conductors shall be:

400/231-VOLT AND 230/133 VOLT, THREE PHASE:

Neutral - Light Blue
Phase A - Gray [Black] [Brown]
Phase B - Black [Gray] [Brown]
Phase C - Brown [Gray] [Black]
Grounding Conductor - Yellow/Green

2.2.4 600 Volt Wire Connectors and Terminals

Shall provide a uniform compression over the entire contact surface. Solderless terminal lugs shall be used on stranded conductors. For use with Copper Conductors: CEI 20-28.

2.2.5 600 Volt Splices

Provide splices with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with CEI 20-24 and CEI 20-33.

a. Provide cast-type splice insulation by means of molded casting process employing a thermosetting epoxy resin insulating material applied by a gravity poured method or by a pressure injected method. Provide component materials of the resin insulation in a packaged form ready for convenient mixing without removing from the package.

   (1) Gravity poured method shall employ materials and equipment contained in an approved commercial splicing kit which includes a mold suitable for the cables to be spliced. When the mold is in place around the joined conductors, prepare the resin mix and pour into the mold.

b. Provide [heavy wall] heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material which shall be applied by a clean burning propane gas torch.

c. 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 coverings or adhesive. It shall be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.2.6 Medium Voltage Cable

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.

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NOTE:
1. For EPR: Cable ratings and insulation thickness are shown in CEI-UNEL 35375.

2. Require compact round conductors only where cable size is limited by the size of the conduit and where the conduit size cannot be increased to accommodate the conductors. Standard cable conductors provided by some manufacturers are compressed or compact round. These meet the requirements if compact round conductors or compressed conductors are not explicitly specified. In compact round conductors, the diameter of the stranded conductor is reduced by approximately 10 percent.

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NOTE: Use only EPR insulation with a tape shield unless specifically requested otherwise by the activity. Values for 133 percent insulation shall be used on all systems other than four-wire, multi-grounded systems, unless specifically directed otherwise.

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2.2.6.1 Cable Configuration

Cable for [9] [20] [____] kV underground distribution system shall be Ozone resistant ethylene-propylene -rubber-insulated (EPR) cable conforming to CEI 20-13, CEI 20-22/2, and CEI-UNEL 35375, as applicable. Cable shall be [single] [three] conductor, employing concentric-lay-stranded, [compact round,]copper conductors. Cable shall have conductor and insulation shielding. Insulation shielding shall be metal tape type. Cable shall be rated [_____] kV with insulation and jacket thickness of [_____]. Cable shall have a polyvinyl chloride jacket.

[2.2.6.2 Paper Insulated Lead Covered (PILC) Cables

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NOTE: PILC cables for use on circuits 10KV or more shall be shielded. PILC cable is recommended only for projects where new cable system will be spliced to existing PILC cable distribution system.

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Cable for [9] [20] [___] kV distribution system shall be solid type impregnated-paper-insulated lead-covered cable conforming to CEI 20-1. Cable shall be [single] [three] conductor, employing concentric-lay-stranded, [compact round,] copper conductor[s]. The cable shall have conductor shielding and insulation shielding over each individual conductor. The sheath shall be of the finest approved special fatigue resistant, age resistant arsenical lead alloy proved by experience and bending machine tests. The sheath shall be smooth and concentric, free

of scars or indentations. Any samples exceeding the specified thickness deviations at any point shall justify complete rejection of adjacent cable without further tests or qualifications. A protective covering of thermoplastic polyethylene shall be applied over the sheath. The rated voltage of the cable shall be [_____] kV [[_____] percent insulation level for [_____] kV system].

]2.2.7 Medium Voltage Cable Terminations

CEI 20-24. Provide terminations including stress control terminator, ground clamp, connectors, and lugs. The terminator shall be the product of one manufacturer, suitable for the type and materials of the cable terminated. Furnish components in the form of a "CE listed" kit, including complete instructions which shall be followed for assembly and installation. Provide terminator as specified herein for terminating single conductor, [or the single conductor of multiconductor,] solid insulated, nonmetallic jacketed type cables for service voltage up to 35 KV indoor and outdoor. Do not use separate parts of copper or copper alloy in contact with aluminum or aluminum alloy parts in the construction or installation of the terminator.

[2.2.7.1 Indoor Terminations/Terminations Within Equipment Enclosures

****

NOTE: Provide with skirts. By including skirts for "indoor" and "within equipment" locations, tracking resistance is significantly improved.

****

The indoor terminator shall be cold-shrink type or heat shrinkable type.

a. Cold-Shrink Type

Terminator shall be a one-piece design, 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 be rated for continuous operation at 90 degree C, with an emergency overload temperature rating of 130 degree C.

b. 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.

][2.2.7.2 Outdoor Terminations

The outdoor terminator shall be cold shrink type or porcelain insulator type.

a. Cold-Shrink Type

Terminator shall be a one-piece design, 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 be rated for continuous operation at 90 degree C, with an emergency overload temperature rating of 130 degree C.

b. Porcelain Insulator Type

The terminator shall comply with requirements of CEI 20-24, except that the requirements of design tightness test need not be met. However, the terminator shall not exude any insulating filler compound under either test or service. The terminator shall consist of a porcelain insulator, copper cable connector-hoodnut assembly and copper aerial lug as required, metal body and supporting bracket, sealed cable entrance, internal stress relief device for shielded cable, and insulating filler compound or material.

][2.2.7.3 Termination; Separable Insulated Connector Type

****

NOTE: Separable insulated connectors, such as load-break elbows, may be used with certain equipment. Where they are required, they should be specified in the section that provides the equipment and cross referenced herein for installation and testing.

****

Provide as specified in Section [____], "[____]".

]2.2.8 Medium Voltage Cable Joints

Provide joints (splices) in accordance with CEI 20-24 suitable for the rated voltage, insulation level, and insulation type of the cable. Upon request, supply manufacturer's design qualification test report. Connectors for joint shall be tin-plated electrolytic copper, having ends tapered and having center stops to equalize cable insertion. Connectors shall be rated for voltage of 35 kV minimum.

a. 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.] [waterproof mastic seal on both ends.]

b. Watertight Taped-Type Joint: Consists of an approved connector, self-fusing or self-bonding insulating tape, self-fusing semiconducting

tape, tinned copper shielding tape or braid, and plastic tape.

[c. Vulcanized-Type Joint: Heat-pressure process of an approved type and employing materials and equipment suitable for the type and voltage of cables for which it is used. Materials used in the jointing process shall be fully and permanently compatible with materials in the cables. Vulcanized-type joints are limited to 5 kV systems.]

[d. 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. Cold-shrink rubber-type joints are limited to 8.7 kV systems.]

[2.2.9 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 CEI 20-28.

]2.2.10 Tape

2.2.10.1 Insulating Tape

CEI EN 60454-3-2 and CEI EN 60454-1, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.2.10.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 02315, "Excavation and Fill".

****

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

****

2.2.10.3 Fireproofing Tape

Furnish tape composed of a flexible conformable unsupported intumescent elastomer. Tape shall be noncorrosive to cable sheath, self-extinguishing, noncombustible, and shall not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.2.11 Pull Rope

Shall be plastic having a minimum tensile strength of 890 N.

2.2.12 Grounding and Bonding Equipment

CEI 11-1 and CEI 64-8. Provide copper clad steel ground rods with diameter adequate to permit driving to full length of the rod, but not less than 19

mm in diameter. Ground rods shall be[3000 mm long][6000 mm long, sectional type] unless otherwise indicated.

2.2.13 Underground Structures

****

NOTE: This paragraph should be edited 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. Designer shall 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 highway loadings may not be available in precast.

See standard sketches UG-1 through UG-7, covering manholes and handholes located at www.efdlant.navfac.navy.mil/lantops_04/bbs.htm. The required sketches should be included on the project drawings.

****

Provide precast concrete underground structures or standard type cast in place [manhole] [and] [handhole] types as indicated, conforming to Law 1086, D.M. 9-1-96, and D.M. 16-1-96 [, except that the spacing of manhole steps or ladder rungs shall not exceed 400 mm]. 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.

2.2.13.1 Cast-In-Place Concrete Structures

Concrete shall conform to Section 03300, "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 Section 04200, "Unit Masonry."] [Concrete block is not allowed in areas subject to aircraft loading.] [Decks and covers subject to aircraft loading shall be as indicated on the drawings.]

2.2.13.2 Precast Concrete Manholes, 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 and handholes.

a. 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 an ultimate 28-day compressive strength of not less than 30 MPa. Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures shall be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

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

(1) Angle of Internal Friction (phi) = 0.523 rad

(2) Unit Weight of Soil (Dry) = 1760 kg/m^3, (Saturated) = 2080 kg/m^3

(3) Coefficient of Lateral Earth Pressure (Ka) = 0.33

(4) Ground Water Level = 900 mm below ground elevation

****

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

Use the second bracketed option for structures that may be subject to aircraft loading. Structures subject to aircraft loading shall be as indicated on the drawings. Structure design requirements must also be shown 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 45,000 kg wheel loads with 1.72 MPa tire pressure.

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

c. For spans of 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 34,000 kg each shall be used.

****

(5) 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 in accordance with Law 1086, D.M. 9-1-96 and D.M. 16-1-96.] [Decks and covers subject to aircraft loading shall be as indicated on the drawings.]

(6) 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.

(7) Each structural component shall be designed for the load combination and positioning resulting in the maximum shear and moment for that particular component.

(8) 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.

c. Construction: Structure top, bottom, and wall shall be of a uniform thickness of not less than 150 mm. 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 300 mm 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 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 14 mm diameter bars around window openings. [The minimum concrete cover for reinforcing steel shall be 50 mm.] Provide drain sumps for precast structures a minimum of 300 mm in diameter and 100 mm deep.

d. 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. 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.

2.2.13.3 Manhole Frames and Covers

Provide cast iron frames and covers for manholes conforming to UNI EN 124. Cast the words "ELECTRIC" and "TELEPHONE" in the top face of power and telephone manhole covers, respectively.

2.2.13.4 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 by approximately 5 mm 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.

[2.2.13.5 Ductile Iron Frames and Covers for Airfield Facilities

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

Ductile iron covers and frames designed for a minimum proof load of 45,000 kg, may be provided in lieu of the steel frames and covers indicated. Covers shall be of the same material as the frames. Proof loading shall be performed in accordance with UNI EN 124. Proof load class 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 accept the ductile iron structure. The finished structure shall be level and non-rocking, with the top flush with the surrounding pavement.

]2.2.14 Polypropylene Handholes

Provide polymer concrete reinforced with a heavy weave fiberglass reinforcing, IP 67 in accordance with CEI EN 60529, with heavy duty traffic type cover and frame in accordance with UNI EN 124.

2.2.15 Cable Supports (Racks, Arms and Insulators)

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

2.2.15.1 Cable Racks

The wall bracket shall be 100 mm by approximately 40 mm by 5 mm channel steel,[1220 mm long (minimum) in manholes] [and] [[___] mm long in handholes]. Slots for mounting cable rack arms shall be spaced at 200 mm

intervals.

2.2.15.2 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 and a maximum of 300 mm.

2.2.15.3 Insulators

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

2.2.16 Cable Tags

Provide as specified in 16050, "Basic Electrical Materials and Methods."

2.3 SOURCE QUALITY CONTROL

2.3.1 Arc-Proofing Test for Cable Fireproofing Materials

Manufacturer shall test [one] [three] sample [assembly] [assemblies, each] consisting of a straight lead tube 300 mm long with a 65 mm outside diameter, and a 3 mm 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 300 (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.

2.3.2 Medium Voltage Cable Qualification and Production Tests

Results of CEI 11-17 and CEI 11-1 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 02361, "Soil Treatment for

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.

****

Underground installation shall conform to CEI 11-17 and CEI 11-1 except as otherwise specified or indicated.

3.1.1 Contractor Damage

The Contractor shall promptly repair any indicated utility lines or systems damaged by Contractor operations. Damage to lines or systems not indicated, which are caused by Contractor operations, shall be treated as "Changes" under the terms of the General Provisions of the contract. If the Contractor is advised in writing of the location of a nonindicated line or system, such notice shall provide that portion of the line or system with "indicated" status in determining liability for damages. Nonindicated utility lines found by the Contractor while scanning the construction site with electromagnetic or sonic tracing equipment will be treated as "indicated" utilities. In any event, the Contractor shall immediately notify the Contracting Officer of any such damage.

3.1.2 Concrete

****

NOTE: Use the first bracketed paragraph when project includes a concrete section in Division 3; otherwise, the second bracketed paragraph may be used.

****

[Concrete work for electrical requirements shall be 20 MPa minimum ultimate 28-day compressive strength with 25 mm maximum aggregate conforming to the requirements of Section 03300, "Cast-in-Place Concrete."]

****

NOTE: If concrete requirements are detailed and no cast-in-place concrete section is to be included in the project specification, refer to Section 03300, "Cast-in-Place Concrete," and select such portions as needed to provide complete requirements.

****

[Shall be composed of fine aggregate, coarse aggregate, portland cement, and water so proportioned and mixed as to produce a plastic, workable mixture. Fine aggregate shall be of hard, dense, durable, clean, and uncoated sand. The coarse aggregate shall be reasonably well graded from 5 mm to 25 mm. The fine and coarse aggregates shall be free from injurious amounts of dirt, vegetable matter, soft fragments or other deleterious substances. Water shall be fresh, clean, and free from salts, alkali, organic matter, and other impurities. Concrete shall have a compressive strength of [20] [30] MPa at the age of 28 days. Slump shall not exceed

[75] [100] mm. Retempering of concrete will not be permitted. Exposed, unformed concrete surfaces shall be given a smooth, wood float finish. Concrete shall be cured for a period of not less than 7 days, and concrete made with high early strength portland cement shall be repaired by patching honeycombed or otherwise defective areas with cement mortar as directed by the Contracting Officer. Air entrain concrete exposed to weather using an air-entraining admixture. Air content shall be between 4 and 6 percent.]

3.1.3 Direct Burial System

****
NOTE: Direct earth burial cables generally require direct burial splices. Observe marker slab requirements previously covered in this specification.
****

Bury cables directly in earth, except under [railroad tracks,] [paved areas,] [and] [roadways,] install cables in conduit encased in concrete. Install cables buried directly in earth in the following manner:

a. Slope ducts to drain.

b. Excavate trenches in which the cables are placed by hand or with mechanical trenching equipment, and provide a minimum cable cover of 610 mm below finished grade for power conductors operated at 600 volts and less, and 770 mm to the top of the cables for over 600 volts. Trenches shall be not less than [150] [200] mm 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. Where two or more cables are laid parallel in the same trench, space cables laterally at not less than 75 mm apart, except that communication cable shall be separated from power cable by a minimum distance of 300 mm.

c. Do not unreel and pull cables into the trench from one end. However, the cable [may] [shall] be unreeled on grade and lifted into position. [Cable bedding and cover shall consist of material which would pass a 6 mm screen with no sharp objects. When rock is encountered, remove to a depth of at least 75 mm below the cable and fill the space with sand or clean earth free from particles larger than 6 mm.] [Cable bedding and cover shall consist of a 75 mm sand bedding with 75 mm more sand placed on top of cable.]

3.1.3.1 Restoration

Replace sod which has been removed, as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, pad construction, and other work to original condition and maintain until final acceptance. Provide necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging or mulching. [Perform work in accordance with Section 02921, "Turf," and Section 02930, "Exterior Plants."]

3.1.3.2 Crossing Cables

Separate cables crossing other cables or metal piping from the other cables or pipe by not less than [75] [300] mm of well tamped earth, in accordance to CEI 11-17.

3.1.3.3 Splicing

Provide cables in one piece without splices between connections except where the distance exceeds the lengths in which cables are manufactured.

3.1.3.4 Bends

Bends in cables shall have an inner radius not less than [those specified by cable manufacturer's for the type of cable specified.] [12 times the cable diameter.]

3.1.3.5 Horizontal Slack

Leave approximately 900 mm 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. [Splices in lead-sheathed or armored cables shall be enclosed in split-type cast-iron splice boxes; after completion of the connection, tightly clamp the box and fill with insulating filler compound.]

3.1.4 Identification Slabs [Markers]

****

NOTE: Use this paragraph for direct buried cable and for direct buried conduit, to mark ends of conduit sleeves under paved areas and to mark location of stubouts.

****

Provide a slab at each change of direction of direct buried cable, over each splice, over the ends of ducts or conduits which are installed under paved areas and roadways, and over ends of stubouts. Identification slabs shall be concrete, approximately 500 mm square by 150 mm thick and shall be set flat in the ground so that the top surface projects not less than 20 mm, nor more than 30 mm above ground. The concrete shall have a compressive strength of not less than 20 MPa 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 directed. Letters or figures shall be approximately 50 mm high and grooves shall be approximately 6 mm 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.

3.1.5 Underground Conduit/Duct Without Concrete Encasement

The type of conduit shall be PVC heavy duty type or rigid metal conduit.

3.1.5.1 Conduit Installation

The top of the conduit shall be not less than 610 mm below grade, and shall have a minimum slope of 75 mm in each 30 meters away from buildings and toward manholes and other necessary drainage points. Run conduit in straight lines except where a change of direction is necessary. Terminate conduits in end-bells where they enter underground structures. As each conduit run is completed, draw a nonflexible testing mandrel not less than 305 mm long with a diameter 6 mm 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. Provide not less than 75 mm clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 75 mm, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 6 mm sieve.

3.1.5.2 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 75 mm concrete cover around ducts. The concrete encasement shall extend at least 1525 mm beyond the edges of paved areas and roads, and 3660 mm beyond the rails on each side of railroad tracks. 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. [Hydraulic jet method shall not be used.]

3.1.5.3 Multiple Conduits

Separate multiple conduits by a minimum distance of 50 mm, except that light and power conduits shall be separated from control, signal, and telephone conduits by a minimum distance of 75 mm. Stagger the joints of the conduits by rows and layers to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly shall consist of base spacers, intermediate spacers, and top spacers to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 3050 mm of conduit assembly.

3.1.6 Underground Duct with Concrete Encasement

****

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. Designer shall contact local telephone company, where applicable, concerning the size of signal manholes and the number and type of signal duct required.

****

Construct underground duct banks of individual conduits encased in concrete. Except where rigid galvanized steel conduit is indicated or specified, the conduit shall be PVC medium duty type. Do not mix different kinds of conduit in any one duct bank. Ducts shall be a minimum of [100] [125] mm in diameter unless otherwise indicated. The concrete encasement surrounding the bank shall be rectangular in cross-section and shall provide at least 75 mm of concrete cover around ducts. Separate conduits by a minimum concrete thickness of [50] [65] mm, except separate light and power conduits from control, signal, and telephone conduits by a minimum concrete thickness of 75 mm.

3.1.6.1 Depth of Encasement

The top of the concrete envelope shall be a minimum of 450 mm below grade[, except under roads and pavement, concrete envelope shall be a minimum of 610 mm below grade] [and under railroad tracks a minimum of 1300 mm below the top of the rails].

3.1.6.2 Slope of Encasement

Duct banks shall have a continuous slope downward toward underground structures and away from buildings with a minimum pitch of 75 mm in 30 meters. Except at conduit risers, changes in direction of runs exceeding a total of 0.175 rad, either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 7.6 meters; sweep bends may be composed of one or more curved or straight sections or combinations thereof. Manufactured bends shall have a minimum radius of 450 mm for use with conduits of less than 75 mm in diameter and a minimum radius of 900 mm for ducts of 75 mm in diameter and larger. Excavate trenches along straight lines from structure to structure before ducts are laid or structure constructed so the elevation can be adjusted, if necessary, to avoid unseen obstruction.

3.1.6.3 Conduit

Terminate conduits in end-bells where ducts enter underground structures. Stagger the joints of the conduits by rows and layers to strengthen the duct bank. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly shall consist of base spacers, intermediate spacers, and top spacers to provide a completely enclosed and locked-in duct bank. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 3 m of duct bank. 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 every other duct spacer assembly and attaching the rod to the spacer assembly.

3.1.6.4 Test Mandrel

As each section of a duct bank is completed from structure to structure, a testing mandrel not less than 300 mm long with a diameter 6 mm less than the inside diameter of the conduit shall be drawn through each conduit, after which a stiff-bristled brush, having the diameter of the conduit

shall be drawn through until the conduit is clear of earth, sand, and gravel particles. Conduit plugs shall then be immediately installed.

3.1.6.5 Connections to Manholes

Duct bank envelopes connecting to underground structures shall be flared to have an enlarged cross-section at the manhole entrance to provide additional shear strength. The dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 305 mm in each direction. The perimeter of the duct bank opening in the underground structure shall be flared toward the inside or keyed to provide for a positive interlock between the duct bank and the wall of the structure. Vibrators shall be used when this portion of the envelope is poured to assure a seal between the envelope and the wall of the structure.

3.1.6.6 Connections to Existing Underground Structures

****

NOTE: Most duct banks do not have reinforcing steel, therefore the first option should be selected. Use the second option only for duct banks with reinforcing steel.

****

For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve the steel in the structure wall. Cut the 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.

3.1.6.7 Connections to Existing Concrete Pads

For duct bank connections to concrete pads, break an opening in the pad out to the dimensions required and preserve the steel in the 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.

3.1.6.8 Connections to Existing Ducts

Where connections to existing duct banks are indicated, excavate the banks to the maximum depth necessary. The banks shall be cut off and loose concrete removed from the conduits before new concrete-encased ducts are installed. A reinforced concrete collar, poured monolithically with the new duct bank, shall be provided to take the shear at the joint of the duct banks. [Remove existing cables which constitute interference with the work.] [Abandon in place the unused ducts and cables which do not interfere with the work.]

3.1.6.9 Partially Completed Duct Banks

During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud, sand, 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 600 mm back into the envelope and a minimum of 600 mm beyond the end of the envelope. Provide one No. 4 bar in each corner, 75 mm from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 300 mm apart. Restrain reinforcing assembly from moving during concrete pouring.

3.1.7 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 weephole or screen to allow water drainage. Provide a plastic pull rope having 900 mm of slack at each end of unused or empty conduits.

3.1.8 Innerducts

Installation shall be as per manufacturer's instructions.

[3.1.9 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.

]3.1.10 Underground Conduit for Feeders Into Buildings

Shall be heavy duty type PVC or galvanized rigid steel from the service equipment to a point 1500 mm beyond the building and projections thereof. Protect the ends of the conduit. Provide threaded metal caps or bushings for metal conduit, and coat the threads with graphite grease or other coating. Clean and plug conduit until conductors are installed. Encase the underground portion of the conduit in a concrete envelope and bury as specified for underground duct with concrete encasement.

3.1.11 Conduit Protection at Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) shall be PVC coated and shall extend from the first coupling or fitting outside either side of the concrete (minimum of 150 mm from penetration).

3.1.12 Installation of Warning and Identification Tape

Provide warning tape for underground direct buried, in conduit, and concrete encased systems. Bury tape with the printed side up at a depth of 305 mm below the top surface of earth or the top surface of the subgrade under pavements.

3.1.13 Underground Structure Construction

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NOTE: This paragraph should be edited 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. Designer shall contact local telephone company, where applicable, concerning the size of all signal manholes and the number and type of signal ducts required. Determine availability since highway or aircraft loadings may not be available in precast.

See standard sketches UG-1 through UG-7, covering manholes and handholes. The required sketches should be included on the project drawings. These sketches can be found at http://www.efdlant.navfac.navy.mil/lantops_04/home.htm.

****

Underground structures shall be of standard type cast-in-place construction as specified herein and as indicated, or may be of 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 UNI 8656. 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.

3.1.13.1 Precast Concrete Construction

Commercial precast structures shall be set on 150 mm of level, 90 percent compacted granular fill, 20 mm to 25 mm size, extending 300 mm beyond the structure on each side. Granular fill shall be compacted by a minimum of four passes with a plate type vibrator. Installation shall additionally conform to the manufacturer's instructions.

3.1.13.2 Pulling-In Irons

Pulling-in irons shall be 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 from the edge of the sump, and in the walls the irons shall be located within 150 mm 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 of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a

pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 150 mm clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 900 mm length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner 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 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 and shall be designed to withstand a minimum pulling-in load of 26,700 N. Irons shall be [hot-dipped galvanized] [zinc-coated] after fabrication.

3.1.13.3 Cable Racks, Arms and Insulators

Cable racks, arms and insulators shall be sufficient to accommodate the cables. Racks in power manholes [and handholes] shall be spaced not more than 900 mm apart, and each manhole [and handhole] wall shall be provided with a minimum of two racks. Racks in signal manholes [and handholes] shall be spaced not more than 420 mm apart with the end rack being no further than 300 mm from the adjacent wall. Methods of anchoring cable racks shall be as follows:

a. Provide a 16 mm diameter by 125 mm long anchor bolt with 75 mm foot cast in structure wall with 50 mm protrusion of threaded portion of bolt into structure. Provide 16 mm steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.

b. Provide concrete channel insert with a minimum load rating of 1200 kg per meter. 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 steel nuts in channel insert to receive 15 mm diameter by 75 mm long steel, square head anchor bolts.

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

3.1.13.4 Grounding in Underground Structures

Provide a bare copper cable on each interior sidewall sized in accordance with CEI 11-1 and CEI 64-8. The cables shall be exothermically welded to the ground rod in the structure, and shall be accessible for future grounding requirements.

3.1.13.5 Field Painting

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NOTE: Include reference to the paint specification when it is included in the project documents.

****

[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.] [Steel frames not buried in masonry and steel covers shall be cleaned of mortar, dirt and grease by an approved blasting process. Surfaces that cannot be cleaned satisfactorily by blasting shall be cleaned to bare metal by wire brushing or other mechanical means. Surfaces contaminated with rust, dirt, oil, grease, or other contaminants shall be washed with solvents until thoroughly cleaned. Immediately after cleaning, surfaces shall be given a crystalline phosphate coating. As soon as practicable after the coating has dried, surfaces shall be primed with a coat of zinc-molybdate primer and one coat of synthetic exterior gloss enamel.] [Primer and paint shall be as specified in Section 09900, "Paint and Coatings."]

3.1.14 Polypropylene Handhole Installation

Install as indicated and in accordance with the manufacturer's instructions.

3.1.15 Cable Pulling

[Test existing ducts 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 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.

3.1.15.1 Cable Lubricants

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

3.1.15.2 Cable Pulling Tensions

Tensions shall not exceed the maximum pulling tension recommended by the cable manufacturer.

3.1.15.3 Installation of Cables in Underground Structures

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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.

****

Do not install cables utilizing the shortest path, but route along those walls providing the longest path and the maximum spare cable lengths. Form cables to closely parallel walls, without interference to 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. In existing manholes, handholes and vaults where new ducts are to be terminated or where new cables are to be installed, modify the existing installation of cables, cable supports and grounding as required for a uniform installation with cables carefully arranged and supported in the same manner as specified for new cables. [Provide [_____] cable racks in each existing underground structure through which cable is run.]

3.1.15.4 Cable Markers (or Tags) in Underground Structures

Provide as specified in Section 16050, "Basic Electrical Materials and Methods."

[3.1.15.5 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, unless otherwise indicated.

]3.1.16 600 Volt Cable Splicing and Terminating

****

NOTE: Direct earth burial cables generally require direct burial splices. Incorporate marker slab requirements previously covered in this specification.

****

Provide splices and terminations to protect 600 volt insulated power and lighting cables from accidental contact, deterioration of coverings and moisture. 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 and handholes.]

3.1.17 Medium Voltage Cable Terminations

Provide terminating devices and materials to protect medium voltage cable terminations from accidental contact, deterioration of coverings, and moisture. Make terminations by using materials and methods specified herein and as designated by the written instruction of the cable manufacturer and termination kit manufacturer. Termination for

high-voltage cables shall be rated, and be capable of withstanding test voltages, in accordance with CEI 20-24. Terminations of single- and multiconductor cables shall include the securing and sealing of the sheath and insulation of the cable conductors, stress relief and grounding of cable shields of shielded cable, and grounding of neutral conductors, metallic sheaths, and armor. Adequately support cables and cable terminations to avoid any excessive strain on the termination and the conductor connection.

3.1.18 Medium Voltage Cable Joints

Provide power cable joints (splices) suitable for continuous immersion in water [and direct burial]. Make joints only in accessible locations in manholes or handholes by using materials and methods specified herein and as designated by the written instructions of the cable manufacturer and the joint kit manufacturer. [Clearly mark joints buried directly in earth by an identification slab.] Size connectors properly for the cable being connected and crimp using a full circle compression tool.

3.1.18.1 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. [Ground ends of insulated sections terminating in potheads at the pothead terminal only.] Provide a bare copper ground connection brought out in a watertight manner and grounded to a ground rod 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.

[3.1.18.2 Lead-Sheathed Cable Joints

Prepare for jointing by cutting the lead sheath back the required distance and belling the remaining cable sheath to prevent damage to the conductor insulation. Clean insulated conductors and tape and cut insulation to expose bare wires for the required distance. Clean conductor thoroughly, then join by a split or slotted tinned copper connector or other approved connector. Solder conductors and connector and wrap joint with compatible semiconducting tape and insulating tape as recommended by the manufacturer so that insulation will be at least equal to the rated insulation of the cable. [For cable over 7500 volts operating voltage, provide cable shield splice.] Center the lead sleeve over the prepared joint, [boil out the area with hot insulating oil,] [fill with an insulating oil] [fill with an insulating compound] and solder seal. [Alternately use a factory-engineered heat shrinkable joint kit to complete the splice. Heat shrinkable joint kit shall contain necessary materials except connector to provide oil stop and oil seal, electrical stress, control, insulation, shielding and environmental sealing. Kit shall allow for external grounding.]

]3.1.19 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.

[3.1.20 Live End Caps

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

]3.1.21 Fireproofing of Cables in Manholes, Handholes and Vaults

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in manholes, handholes, and vaults.

3.1.21.1 Fireproofing Tape

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

[3.1.21.2 Tape-Wrap

Tape-wrap lead-sheathed, other 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 thick plastic tape, and shall extend not less than 25.4 mm into the duct. Even out irregularities of the cable, such as at splices, with insulation putty before applying tape.

]3.1.22 Grounding Systems

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NOTE: The Designer must 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 in accordance to CEI 11-1, CEI 64-8, or as listed below, whichever is lower:

[Generating and control equipment
1000 volts and over 1 ohm]

[[Main substations] [, distribution substations] [, switching stations] [, primary distribution stations enclosed by fences]

[500 kVA or less 5 ohms]

[500 kVA to 1000 kVA	5 ohms]
[1000 kVA or over	3 ohms]]
[Pad-mounted transformers without protective fences	5 ohms]
[Ground in manholes, handholes, and vaults	5 ohms]
[Grounding other metal enclosures of primary voltage electrical and electrically-operated equipment	5 ohms]
[Grounded secondary distribution system neutral and noncurrent-carrying metal parts associated with distribution systems and grounds not otherwise covered	5 ohms]

When work in addition to that indicated or specified is directed in order to obtain the specified ground resistance, the provisions of the contract covering "Changes" shall apply.

3.1.22.1 Grounding Electrodes

Provide cone pointed ground rods driven full depth plus 150 mm, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.

3.1.22.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, [excepting specifically those connections for which access for periodic testing is required,] 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.

3.1.22.3 Grounding Conductors

Grounding conductors shall be stranded-bare copper conforming to CEI 7-1, for sizes 16 sq. mm. and larger, and shall be solid-bare copper conforming to CEI 20-20/1 for sizes 10 sq. mm. and smaller. Cable sheaths, cable shields, conduit, and equipment shall be grounded in accordance with

CEI 11-1.

3.1.22.4 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.

[3.1.22.5 Ground Rod Connections

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NOTE: Do not use this paragraph except when insulated ground is required; for others, use grounding connection paragraph.
****

Connect ground rods only to insulated copper ground conductor and weld the connection. Insulate entire area of the rod in the vicinity of the weld and the connecting wire and seal against moisture penetration.

][3.1.22.6 Fence Grounding

[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 300 mm below grade. Attach a 25 sq. mm. copper conductor, by exothermic weld to the ground rods and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 300 mm of fence mesh and fasten by two approved bronze compression fittings, one to bond wire to post and the other to bond wire to fence. Each gate section shall be bonded to its gatepost by a 3 mm by 25 mm flexible braided copper strap and ground post clamps. Clamps shall be of the anti-electrolysis type.]

]3.1.22.7 Manhole Grounding

Loop a 95 mm^2 grounding conductor around the interior perimeter, approximately 300 mm above finished floor. Secure the conductor to the manhole walls at intervals not exceeding 900 mm. Connect the conductor to the manhole grounding electrode with 95 mm^2 conductor. Connect all incoming 95 mm^2 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 10 mm^2 conductor. Provide direct connections to the grounding conductor with 600 volt insulated, full size conductor for each grounded neutral of each feeder circuit which is spliced within the manhole.

[3.1.23 Special Conditions

During the construction of duct banks and underground structures located in streets, the streets shall remain open to traffic. Plan and execute the work to meet this condition. At locations where duct banks cross railroad

tracks and the work requires closing of the tracks, secure permission from the Contracting Officer for each track closure.

]3.1.24 Excavating, Backfilling, and Compacting

Provide under this section as specified in Section 02315, "Excavation and Fill".

3.1.25 Reconditioning of Surfaces

3.1.25.1 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 with sod of equal quality 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.

3.1.25.2 Paving Repairs

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

****

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 to 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 in accordance with Section 02951 "Pavement Removal and Replacement."]

3.2 FIELD QUALITY CONTROL

3.2.1 Performance of Field Acceptance Checks and Tests

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NOTE: Use Section 16081 when medium voltage cable and terminations are in job.

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Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests[in accordance with Section 16081, "Apparatus Inspection and Testing"].

3.2.1.1 600 Volt Cable Tests

Perform tests in accordance with CEI EN 60811-1-1 and CEI 64-8, after wiring is completed, connected, and ready for operation, but prior to placing systems in service and before any branch circuit breakers are closed.

a. Visual and Mechanical Inspection

(1) Inspect cables for physical damage and proper connection in accordance with contract plans and specifications.

(2) Check cable color coding for compliance with contract specifications.

b. Electrical Tests

(1) Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts DC for 1 minute. Minimum insulation - resistance values shall not be less than 50 megohms.

(2) Perform continuity test to insure proper cable connection.

3.2.1.2 Medium Voltage Cables

Perform tests in accordance to CEI 11-17 after installation of cable, splices, and terminators and before terminating to equipment.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable supplied is 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 CEI 11-17 or manufacturer's minimum allowable bending radius.

(5) Inspect for proper fireproofing.

[(6) If cables are terminated through window-type CT's, make an inspection to verify that neutrals and grounds are properly terminated for proper operation of protective devices.]

(7) Visually inspect jacket and insulation condition.

(8) 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 300 meters of cable must be investigated and justified. Test voltages shall comply with CEI 11-17.

(2) Perform a DC high-potential test on all cables. Adhere to precautions and limits as specified in the applicable CEI Standard for the specific cable. Test procedure shall be in accordance with CEI 11-17, and the results for each cable test shall be in accordance with CEI 11-17 recorded as specified herein.

(a) Current-sensing circuits in test equipment shall measure only the leakage current associated with the cable under test and shall not include internal leakage of the test equipment.

(b) Record wet- and dry-bulb temperatures or relative humidity and temperature.

(c) Test each section of cable individually.

(d) Individually test each conductor with all other conductors grounded; Ground all shields.

(e) Terminations shall be properly corona-suppressed by guard ring, field reduction sphere, or other suitable methods as necessary.

(f) Ensure that the maximum test voltage does not exceed the limits for terminators specified in CEI Standards or manufacturer's specifications.

(g) Apply the DC high-potential test in at least five equal increments until maximum test voltage is reached. No increment shall exceed the voltage rating of the cable. Record DC leakage current at each step after a constant stabilization time consistent with system charging current.

(h) Raise the conductor to the specified maximum test voltage and hold for fifteen (15) minutes. Record readings of leakage current at 30 seconds and one minute and at one-minute intervals thereafter. Provide a graphic plot of readings with leakage current (Y axis) versus voltage (X axis) at each increment.

(i) Reduce the conductor test potential to zero and measure residual voltage at discrete intervals.

(j) Apply grounds for a time period adequate to drain all insulation stored charge.

(k) When new cables are spliced into existing cables, the DC high-potential test shall be performed on the new cable prior to splicing. After test results are approved for new cable and the splice is completed, an insulation-resistance test and a shield-continuity test shall be performed on the length of new and existing cable including the splice. After a

satisfactory insulation-resistance test, a DC high-potential test shall be performed on the completed cable system utilizing a test voltage 75% of new cable tested value.

3.2.1.3 Grounding System

a. Visual and mechanical inspection

(1) Inspect ground system for compliance with contract plans and specifications

b. Electrical tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger 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.

3.2.2 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.

****

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. Modify sketches as required for project.

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

NOTE: The Sketches can be found at http://www.efdlant.navfac.navy.mil/lantops_04/home.htm. in ACAD format under CAD Details/Electrical and in pdf format under LINKS/NAVFAC Criteria Home Page/Publications/Guide Specifications/Graphics.

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NOTE: Suggestions for improvement of this specification will be welcomed using the "Agency Response Form" located in SPECSINTACT under "System Directory" or DD Form 1426. Suggestions should be forwarded to:

Atlantic Division
Naval Facilities Engineering Command
Attention EICO
1510 Gilbert Street
Norfolk, VA 23511-2699

FAX: (757) 322-4416 or DSN 262-4416

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-- End of Section --