
USACE / NAVFAC / AFCEA UFGS-16370A (July 2002)

Preparing Activity: USACE Superseding
UFGS-16370A (May 2001)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UML dated 22 December 2004

Latest change indicated by CHG tags

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DIVISION 16 - ELECTRICAL

SECTION 16370A

ELECTRICAL DISTRIBUTION SYSTEM, AERIAL

07/02

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SECTION 16370A

ELECTRICAL DISTRIBUTION SYSTEM, AERIAL 07/02

NOTE: This guide specification covers the requirements for aerial electrical distribution systems using wood, steel, aluminum, and concrete poles.

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

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

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.

PART 1 GENERAL

1.1 REFERENCES

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

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C135.1	(1979) Galvanized Steel Bolts and Nuts for Overhead Line Construction
ANSI C135.14	(1979) Staples with Rolled or Slash Points for Overhead Line Construction
ANSI C135.2	(1999) Threaded Zinc-Coated Ferrous Strand-Eye Anchor Rods and Nuts for Overhead Line Construction
ANSI C135.22	(1988) Galvanized Ferrous Pole-Top Insulator Pins with Lead Threads for Overhead Line Construction
ANSI C135.30	(1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction
ANSI C135.4	(1987) Zinc-Coated Ferrous Eyebolts and Nuts for Overhead Line Construction
ANSI C29.1	(1988; R 2002) Test Methods for Electrical Power Insulators
ANSI C29.2	(1992; R 1999) Insulators - Wet-Process Porcelain and Toughened Glass - Suspension Type
ANSI C29.3	(1986; R 2002) Wet Process Porcelain Insulators - Spool Type
ANSI C29.4	(1989; R 2002) Wet-Process Porcelain Insulators - Strain Type
ANSI C29.5	(1984; R 2002) Wet-Process Porcelain Insulators - Low- and Medium-Voltage Types
ANSI C29.6	(1996; R 2002) Wet-Process Porcelain Insulators - High-Voltage Pin Type
ANSI C29.8	(1985; R 2002) Apparatus, Cap and Pin Type Wet-Process Porcelain Insulators -
ANSI C29.9	(1983; R 2002) Wet-Process Porcelain Insulators - Apparatus, Post-Type
ANSI C37.32	(2002) High-Voltage Switches, Bus Supports, and Accessories - Schedules of Preferred Ratings, Construction Guidelines and Specifications
ANSI C57.12.20	(1997) Overhead Type Distribution Transformers, 500 KVA and Smaller: High Voltage 34 500 Volts and Below: Low Voltage, 7970/13 800 Y Volts and Below
ANSI C62.2	(1987; R 1994) Guide for the Application of Gapped Silicon-Carbide Surge Arresters

for Alternating Current Systems

ANSI O5.1 (2002) Specifications and Dimensions for Wood Poles

AMERICAN WOOD-PRESERVERS' ASSOCIATION (AWPA)

AWPA C25 (2001) Sawn Crossarms - Preservative Treatment by Pressure Processes

AWPA C4 (1999) Poles - Preservative Treatment by Pressure Processes

AWPA P1/P13 (2001) Standard for Creosote Preservative

AWPA P5 (2002) Standard for Waterborne Preservatives

AWPA P8 (2001) Standard for Oil-Borne Preservatives

AWPA P9 (2001) Standards for Solvents and Formulations for Organic Preservative Systems

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M (2002) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 153/A 153M (2004) Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A 36/A 36M (2004) Carbon Structural Steel

ASTM A 475 (2003) Zinc-Coated Steel Wire Strand

ASTM A 575 (1996; R 2002) Steel Bars, Carbon, Merchant Quality, M-Grades

ASTM A 576 (1990b; R 2000) Steel Bars, Carbon, Hot-Wrought, Special Quality

ASTM B 1 (2001) Hard-Drawn Copper Wire

ASTM B 117 (2002) Operating Salt Spray (Fog) Apparatus

ASTM B 228 (2004) Concentric-Lay-Stranded Copper-Clad Steel Conductors

ASTM B 230/B 230M (1999; R 2004) Aluminum 1350-H19 Wire for Electrical Purposes

ASTM B 231/B 231M (2004) Concentric-Lay-Stranded Aluminum 1350 Conductors

ASTM B 232/B 232M (2001e1) Concentric-Lay-Stranded Aluminum Conductors, Coated-Steel Reinforced (ACSR)

ASTM B 398/B 398M (2002) Aluminum-Alloy 6201-T81 Wire For

Electrical Purposes

ASTM B 399/B 399M	(2004) Concentric-Lay-Stranded Aluminum-Alloy 6201-T81 Conductors
ASTM B 416	(1998; R 2002) Concentric-Lay-Stranded Aluminum-Clad Steel Conductors
ASTM B 8	(2004) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D 1654	(1992; R 2000) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 4059	(2000) Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography
ASTM D 923	(1997) Sampling Electrical Insulating Liquids
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)	
IEEE C2	(2002) National Electrical Safety Code
IEEE C37.34	(1994) Test Code for High-Voltage Air Switches
IEEE C37.41	(2000) Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories
IEEE C37.60	(2003) Requirements for Overhead, Pad Mounted, Dry Vault and Submersible Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems Up to 38 kV
IEEE C37.63	(1997) Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizers for AC Systems
IEEE C57.12.00	(2000) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13.2	(1991) Standard Conformance Test Procedures for Instrument Transformers
IEEE C57.15	(1999) Requirements, Terminology, and Test Code for Step-Voltage Regulators
IEEE C57.19.00	(1991; R 1997) Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings

IEEE C57.19.01	(2000) Performance Characteristics and Dimensions for Outdoor Apparatus Bushings
IEEE C57.98	(1994) Guide for Transformer Impulse Tests
IEEE C62.1	(1989; R 1994) Gapped Silicon-Carbide Surge Arresters for AC Power Circuits
IEEE C62.11	(1999) Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1KV)
IEEE Std 100	(2000) IEEE Standard Dictionary of Electrical and Electronics Terms
IEEE Std 18	(2002) Shunt Power Capacitors
IEEE Std 242	(2001) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE Std 399	(1997) Recommended Practice for Power Systems Analysis - Brown Book
IEEE Std 404	(2000) Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V Through 500 000 V
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1) Normal Measurements

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-70-547	(2000) Weather Resistant Polyethylene Covered Conductors
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NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA HV 2	(1991; R 1996; R 2002) Application Guide for Ceramic Suspension Insulators
NEMA ICS 6	(1993; R 2001) Industrial Control and Systems: Enclosures
NEMA LA 1	(1992; R 1999) Surge Arresters
NEMA SG 2	(1993) High Voltage Fuses
NEMA WC 74	(2000) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code
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U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1728H-701 (1993) Wood Crossarms (Solid and Laminated), Transmission Timbers and Pole Keys

UNDERWRITERS LABORATORIES (UL)

UL 467 (1993; Rev thru Feb 2001) Grounding and Bonding Equipment

UL 486A (1997; Rev thru May 2001) Wire Connectors and Soldering Lugs for Use with Copper Conductors

UL 486B (1997; Rev thru May 2001) Wire Connectors for Use with Aluminum Conductors

1.2 GENERAL REQUIREMENTS

NOTE: Select the features and fill in blanks with selections appropriate for the design condition and in accordance with guidance contained in TM 5-811-1.

1.2.1 Terminology

Terminology used in this specification is as defined in IEEE Std 100.

1.2.2 Service Conditions

NOTE: See TM 5-811-1 for guidance regarding service conditions. Retain or add the required conditions.

Provide seismic requirements, if a Government designer (either Corps office or A/E) is the Engineer of Record and show on the drawings. Delete the bracketed phrase if seismic details are not included. Sections 13080, 15070A and 16070A, properly edited, must be included in the contract documents.

Items provided under this section shall be specifically suitable for the following service conditions. Seismic details shall conform to Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 15070A SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT, and 16070A SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT [as indicated].

- a. Fungus Control [_____]
- b. Altitude [_____]
- c. Ambient Temperature [_____]
- d. Frequency [_____]

- e. Seismic Parameters [_____]
- f. Corrosive Areas [_____]
- g. [_____]

1.3 SUBMITTALS

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

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

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

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

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Electrical Distribution System

Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams and other information necessary to define the installation and enable the Government to check conformity with the requirements of the contract drawings. Detail drawings shall as a minimum include:

- a. Constant current regulators.
- b. Poles.
- c. Calculations for steel poles and power installed screw foundations.
- d. Crossarms.
- e. Transformers.
- f. Automatic circuit reclosers.
- g. Pole top switches.
- h. Conductors.
- i. Insulators.
- j. Surge arresters.

If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures shall be submitted with the detail drawings. Approved departures shall be made at no additional cost to the Government.

Detail drawings shall show how components are assembled, function together and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall consist of the following:

- a. Detail drawings showing physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. Optional items shall be clearly identified as included or excluded.
- b. Internal wiring diagrams of equipment showing wiring as actually provided for this project. External wiring connections shall be clearly identified.

As-Built Drawings

The as-built drawings shall be a record of the construction as installed. The drawings shall include the information shown on the contract drawings as well as deviations, modifications, and changes from the contract drawings, however minor. The as-built drawings shall be kept at the job site and updated daily. The as-built drawings shall be a full sized set of prints marked to reflect deviations, modifications, and changes. The as-built

drawings shall be complete and show the location, dimensions, part identification, and other information. Additional sheets may be added. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, the Contractor shall submit three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction.

The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within ten calendar days from the time the drawings are returned to the Contractor.

SD-03 Product Data

Fault Current Analysis
Protective Device
Coordination Study

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

Nameplates

Catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents.

Material and Equipment

A complete itemized listing of equipment and materials proposed for incorporation into the work. Each entry shall include the item number, the quantity of items proposed, and the name of the manufacturer of the item.

General Installation Requirements

As a minimum, installation procedures for regulators, transformers and reclosers. Procedures shall include diagrams, instructions, and precautions required to install, adjust, calibrate, and test the devices and equipment.

SD-06 Test Reports

Factory Tests

Certified factory test reports shall be submitted when the manufacturer performs routine factory tests, including tests required by standards listed in paragraph REFERENCES. Results of factory tests performed shall be certified by the manufacturer, or an approved testing laboratory, and submitted within 7 days

following successful completion of the tests specified in applicable publications or in these specifications.

Field Testing

A proposed field test plan [20] [30] [_____] days prior to testing the installed system. No field test shall be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Operating Tests[; G][; G, [_____]]

[Six] [_____] copies of the information described below in 215.9 by 279.4 mm (8-1/2 by 11 inch) 8-1/2 by 11 inch binders having a minimum of 5 rings, and including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

- a. A list of equipment used, with calibration certifications.
- b. A copy of measurements taken.
- c. The dates of testing.
- d. The equipment and values to be verified.
- e. The condition specified for the test.
- f. The test results, signed and dated.
- g. A description of adjustments made.

SD-07 Certificates

Material and Equipment

Where materials or equipment are specified to conform to the standards of the Underwriters Laboratories (UL) or to be constructed or tested, or both, in accordance with the standards of the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), or the National Electrical Manufacturers Association (NEMA), the Contractor shall submit proof that the items provided under this section of the specifications conform to such requirements. The label of, or listing by, UL will be acceptable as evidence that the items conform thereto. Either a certification or a published catalog specification data statement, to the effect that the item is in accordance with the referenced ANSI or IEEE standard, will be acceptable as evidence that the item conforms thereto. A similar certification or published catalog specification data statement to the effect that the item is in accordance with the referenced NEMA standard, by a company listed as a member company of NEMA, will be acceptable as evidence that the item conforms thereto. In lieu of such certification or published data, the Contractor may submit a certificate from a recognized testing agency equipped and competent to perform such services, stating that the items have been tested and that they conform to the requirements listed, including methods of testing of the specified agencies.

SD-10 Operation and Maintenance Data

Electrical Distribution System

[Six] [_____] copies of Operation and Maintenance manuals electrical distribution system shall be provided, within [7] [_____] calendar days following the completion of tests and shall include assembly, installation, operation and maintenance instructions, spare parts data which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked. Manuals shall also include data outlining detailed procedures for system startup and operation, and a troubleshooting guide which lists possible operational problems and corrective action to be taken. A brief description of all equipment, basic operating features, and routine maintenance requirements shall also be included. Documents shall be bound in a binder marked or identified on the spine and front cover. A table of contents page shall be included and marked with pertinent contract information and contents of the manual. Tabs shall be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare-parts data. Index sheets shall be provided for each section of the manual when warranted by the quantity of documents included under separate tabs or dividers. Three additional copies of the instructions manual shall be provided within 30 calendar days following the manuals.

Three additional copies of the instructions manual within 30 calendar days following the approval of the manuals.

1.4 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Oil filled transformers and switches shall be stored in accordance with the manufacturer's requirements. Wood poles held in storage for more than 2 weeks shall be stored in accordance with ANSI O5.1. Handling of wood poles shall be in accordance with ANSI O5.1, except that pointed tools capable of producing indentations more than inch in depth shall not be used. Metal poles shall be handled and stored in accordance with the manufacturer's instructions.

1.5 EXTRA MATERIALS

One additional spare fuse or fuse element for each furnished fuse or fuse element shall be delivered to the Contracting Officer when the electrical system is accepted. Two complete sets of all special tools required for maintenance shall be provided, complete with a suitable tool box. Special tools are those that only the manufacturer provides, for special purposes (to access compartments, or operate, adjust, or maintain special parts).

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

Products shall conform to the following requirements. Items of the same

classification shall be identical including equipment, assemblies, parts, and components.

2.2 STANDARD PRODUCT

Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.3 NAMEPLATES

2.3.1 General

Each major component shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a nameplate securely attached to the equipment. Equipment containing liquid-dielectrics shall have the type of dielectric on the nameplate. Nameplates shall be made of noncorrosive metal. As a minimum, nameplates shall be provided for transformers, regulators, circuit breakers, capacitors, meters and switches.

2.3.2 Liquid-Filled Transformer Nameplates

**NOTE: Coordinate Nameplate C information with the
manufacturer. Select 50 ppm for Army projects and 2
ppm for Air Force projects.**

Power transformers shall be provided in accordance with IEEE C57.12.00. Nameplates shall indicate the number of liters gallons and composition of liquid-dielectric, and shall be permanently marked with a statement that the transformer dielectric to be supplied is non-polychlorinated biphenyl. If transformer nameplate is not so marked, the Contractor shall furnish manufacturer's certification for each transformer that the dielectric is non-PCB classified, with less than [50] [2] ppm PCB content in accordance with paragraph LIQUID DIELECTRICS. Certifications shall be related to serial numbers on transformer nameplates. Transformer dielectric exceeding the [50] [2] ppm PCB content or transformers without certification will be considered as PCB insulated and will not be accepted.

2.4 CORROSION PROTECTION

2.4.1 Aluminum Materials

[Aluminum shall not be used in contact with earth or concrete. Where aluminum conductors are connected to dissimilar metal, fittings conforming to UL 486B shall be used.] [Aluminum shall not be used.]

2.4.2 Ferrous Metal Materials

2.4.2.1 Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A 153/A 153M and ASTM A 123/A 123M.

2.4.2.2 Equipment

NOTE: A 120-hour test will be specified in a noncorrosive environment and a 480-hour test will be specified in a corrosive environment.

Equipment and component items, including but not limited to transformers and ferrous metal luminaires not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand [120] [480] hours of exposure to the salt spray test specified in ASTM B 117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6 mm (1/16 inch) 1/16 inch from the test mark. The described test mark and test evaluation shall be in accordance with ASTM D 1654 with a rating of not less than 7 in accordance with TABLE 1, (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

2.4.3 Finishing

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory shall be as specified in Section 09900 PAINTS AND COATINGS.

2.5 CONDUCTORS, CONNECTORS, AND SPLICES

NOTE: Justify the selection of copper or aluminum, based upon an analysis using life, environmental, and cost factors.

2.5.1 Aluminum-Composition Conductors

[All-aluminum-conductors, AAC, shall be alloy 1350-H19 and comply with ASTM B 230/B 230M and ASTM B 231/B 231M.] [All-aluminum-alloy-conductors, AAAC, shall be alloy 6201-T81 and comply with ASTM B 398/B 398M and ASTM B 399/B 399M.] [Aluminum-conductor-steel-reinforced, ACSR, shall comply with ASTM B 232/B 232M.]

2.5.2 Copper Conductors

Hard-drawn-copper conductors shall comply with ASTM B 1 and ASTM B 8 as appropriate for the conductor size.

2.5.3 Connectors and Splices

Connectors and splices shall be of copper alloys for copper conductors, aluminum alloys for aluminum-composition conductors, and a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors. Aluminum-composition and aluminum-composition to copper shall comply with UL 486B, and copper-to-copper shall comply with UL 486A.

2.6 MEDIUM-VOLTAGE LINES

2.6.1 Bare Medium-Voltage Lines

Bare medium-voltage line conductors shall be [all-aluminum-conductor, AAC;] [all-aluminum-alloy-conductor, AAAC;] [aluminum-conductor-steel-reinforced, ACSR;] [hard-drawn-copper, CU]. Conductor types shall not be mixed on any

project, unless specifically indicated. Conductors larger than No. 2 AWG shall be stranded.

2.6.2 Insulated Medium-Voltage Lines

NOTE: Select XLP for short life configuration.
Select EPR for long life configuration. See TM
5-811-1 for guidance.

Insulated medium-voltage line conductors shall be of the factory-assembled, messenger-supported type, having a rated circuit voltage of [5] [15] [25] [_____] kV, and a 133 percent insulation level. Conductor material shall be [_____] . Insulation shall be [cross-linked thermosetting polyethylene (XLP) conforming to [_____]] [ethylene-propylene-rubber (EPR) conforming to [_____]] [_____] . Messengers shall be zinc-coated steel, aluminum-clad-steel, copper-clad-steel, or composite-copper and copper-clad steel.

2.7 LOW-VOLTAGE LINES

NOTE: Due to both space requirements and the
unattractive appearance, line conductors on
secondary racks will be limited to special
circumstances.

Low-voltage line conductors shall be of the neutral-supported secondary and service drop type with [thermoplastic insulation in accordance with [_____]] [cross-linked thermosetting polyethylene (XLP) insulation in accordance with [_____]] [weather-resistant polyolefin-covered type conforming to ICEA S-70-547]. Neutral-supported secondary and service drop conductors shall be [insulated copper with bare hard-drawn-copper or copper-clad steel neutrals] [insulated aluminum with bare 1350 alloy aluminum or ACSR neutrals]. Conductors on secondary racks may be provided in lieu of neutral-supported cable for pole line circuits where necessary clearances are available.

2.8 POLES AND HARDWARE

NOTE: Use "class" for wood poles and "strength" for
concrete and steel poles. Follow local utility
practice regarding grounding metallic items on
poles, after coordination with local DPW/BCE.
Specify clearances and climbing space in accordance
with IEEE C2 or applicable state code.

Poles shall be of lengths and [classes] [strengths] indicated.

2.8.1 Wood Poles

NOTE: Waterborne preservatives should not be used
in humid and/or termite infested areas.

Wood poles shall comply with ANSI O5.1, and shall be pressure treated in accordance with AWPA C4, with creosote conforming to AWPA P1/P13 or with oil-borne preservatives and petroleum conforming to AWPA P8 and AWPA P9, respectively, and waterborne preservatives conforming to AWPA P5. Waterborne preservatives shall be either chromated or ammoniacal copper arsenate. Any species listed in ANSI O5.1 for which a preservative treatment is not specified in AWPA C4, shall not be used; northern white cedar, if treated as specified for western red cedar, and western fir, if treated as specified for Douglas fir, may be used. Wood poles shall have pole markings located approximately 3 m 10 feet from pole butts for poles 15.2 m (50 feet) 50 feet or less in length, and 4 m 14 feet from the pole butts for poles longer than 16.8 m (55 feet) 55 feet in length. Poles shall be machine trimmed by turning smooth full length, and shall be roofed, gained, and bored prior to pressure treatment. Where poles are not provided with factory-cut gains, metal gain plates shall be provided.

2.8.2 Steel Poles

Steel poles shall be designed to withstand the loads specified in IEEE C2 multiplied by the appropriate overload capacity factors, shall be hot-dip galvanized in accordance with ASTM A 123/A 123M and shall not be painted. Poles shall have tapered tubular members, either round in cross-section or polygonal, and comply with strength calculations performed by a registered professional engineer. Calculations shall be submitted in accordance with the detail drawings portion of paragraph SUBMITTALS. Pole shafts shall be one piece. Poles shall be welded construction with no bolts, rivets, or other means of fastening except as specifically approved. Pole markings shall be approximately 900 to 1270 mm 3 to 4 feet above grade and shall include manufacturer, year of manufacture, top and bottom diameters, length, and a loading tree. Attachment requirements shall be provided as indicated, including grounding provisions. Climbing facilities are not required. Bases shall be of the anchor-bolt-mounted type.

2.8.3 Concrete Poles

**NOTE: In areas where freezing temperatures occur,
the minimum compressive strength given for concrete
in spun poles should be increased in line with
concrete design for such temperatures.**

Concrete poles shall be designed to withstand the loads specified in IEEE C2 multiplied by the appropriate overload capacity factors. Poles shall be reinforced or prestressed, either cast or spun. Spun poles shall be manufactured by a centrifugal spinning process with concrete pumped into a polished round tapered metal mold. Concrete for spun poles shall have a compressive strength of at least 34.5 MPa (5000 psi) 5000 psi at 28 days; steel wire shall have an ultimate tensile strength of at least 827 MPa (120,00 psi); 120,000 psi; and reinforcing bars shall have an ultimate tensile strength of at least 276 MPa (40,000 psi). 40,000 psi. After the high speed spinning action is completed, a spun pole shall be cured by a suitable wet steam process. Spun poles shall have a water absorption of not greater than three percent to eliminate cracking and to prevent erosion. Concrete poles shall have hollow shafts. Poles shall have a hard, smooth, nonporous surface that is resistant to soil acids, road salts, and attacks of water and frost. Poles shall not be installed for at least 15 days after manufacture. Fittings and brackets that conform to the

concrete pole design shall be provided. Poles shall conform to strength calculations performed by a registered professional engineer and submitted in accordance with detail drawings portion of paragraph SUBMITTALS.

2.8.4 Pole Line Hardware

NOTE: In hot humid marine atmospheres, galvanized steel pole-line hardware may not be acceptable and only hot-dip galvanized malleable or ductile iron should be permitted. Local usage should be checked.

Zinc-coated hardware shall comply with ANSI C135.1, ANSI C135.2, ANSI C135.4, ANSI C135.14 ANSI C135.22. Steel hardware shall comply with ASTM A 575 and ASTM A 576. Hardware shall be hot-dip galvanized in accordance with ASTM A 153/A 153M. Pole-line hardware shall be hot-dip galvanized [steel.] [steel, except anchor rods of the copper-molten welded-to-steel type with nonferrous corrosion-resistant fittings shall be used]. Washers shall be installed under boltheads and nuts on wood surfaces and elsewhere as required. Washers used on through-bolts and double-arming bolts shall be approximately 57.2 mm square 2-1/4 inches square and 4.8 mm (3/16 inch) 3/16 inch thick. The diameter of holes in washers shall be the correct standard size for the bolt on which a washer is used. Washers for use under heads of carriage-bolts shall be of the proper size to fit over square shanks of bolts. Eye bolts, bolt eyes, eyenuts, strain-load plates, lag screws, guy clamps, fasteners, hooks, shims, and clevises shall be used wherever required to support and to protect poles, brackets, crossarms, guy wires, and insulators.

2.8.5 Armless Construction

Pole mounting brackets for line-post or pin insulators and eye bolts for suspension insulators shall be as shown. Brackets shall be attached to poles with a minimum of two bolts. Brackets may be either provided integrally as part of an insulator or attached to an insulator with a suitable stud. Bracket mounting surface shall be suitable for the shape of the pole. Brackets for wood poles shall have wood gripping members. Horizontal offset brackets shall have a 5-degree uplift angle. Pole top brackets shall conform to ANSI C135.22, except for modifications necessary to provide support for a line-post insulator. Brackets shall provide a strength exceeding that of the required insulator strength, but in no case less than a 12.5 kN (2800 pound) 2800 pound cantilever strength.

2.8.6 Guy Assemblies

Guy assemblies shall be [aluminum-clad steel in accordance with ASTM B 416] [copper-clad steel in accordance with ASTM B 228] [or] [zinc-coated steel in accordance with ASTM A 475]. Guy assemblies, including insulators and attachments, shall provide a strength exceeding the required guy strength. Three-eye thimbles shall be provided on anchor rods to permit attachment of individual primary, secondary, and communication down guys. Anchors shall provide adequate strength to support all loads. Guy strand shall be [3] [7] strand. Guy material shall be [Class [30 HS] [30 EHS] copper-clad steel] [Class [A] [B] [C] zinc-coated-steel [utilities] [high-strength] [extra-high-strength] grade] [or] [aluminum-clad-steel-strand], with a minimum breaking strength [not less than 26.7 kN (6000 pounds)] [_____] kN ([_____] pounds) [6000 pounds] [[_____] pounds] [as shown], except where two or more guys are used to provide the required strength. Guy rods shall

be not less than [2.1 m (7 feet)] [2.4 m (8 feet)] [7] [8] feet in length by [15.9 mm (5/8 inch)] [19.1 mm (3/4 inch)] [25.4 mm (1 inch)] [5/8] [3/4] [1] inch in diameter.

2.9 INSULATORS

NOTE: See TM 5-811-1 for guidance regarding insulators.

Insulators shall comply with NEMA HV 2 for general requirements. Suspension insulators shall be used at corners, angles, dead-ends, other areas where line insulators do not provide adequate strength, and as indicated. Mechanical strength of suspension insulators and hardware shall exceed the rated breaking strength of the attached conductors.

2.9.1 Medium-Voltage Line Insulators

NOTE: Specify the first value for dry areas or limited fog areas with moderate industry contamination. Specify the second value for more heavily contaminated areas.

Medium-voltage line insulators shall comply with ANSI C29.2, ANSI C29.5, and ANSI C29.6, and as applicable. Ratings shall not be lower than the ANSI classes indicated in TABLE I. Horizontal line-post insulators shall be used for armless construction and shall have the same mechanical and electrical ratings as vertical line-post insulators for the ANSI class indicated, but shall be modified to be suitable for horizontal installation. Where line-post insulators are used for angles greater than 15 degrees, clamp-top fittings shall be provided as well as for other locations shown. Conductor clamps for use with clamp-top, line-post insulators shall be hot-dip galvanized malleable iron for copper conductors and aluminum alloy for aluminum-composition conductors. Either line-post or pin insulators may be used for crossarm construction. Pin insulators for use on voltages in excess of 6 kV phase-to-phase shall be radio-interference-freed or else line-post insulators shall be used.

TABLE I

MINIMUM ANSI RATING OF MEDIUM-VOLTAGE INSULATORS BY CLASS

Voltage Level	Line-Post	Pin	Suspension
Up to 5 kV	57-1 or 11	55-3	One 52-1
	57-1 or 11	55-5	Two 52-1
6 kV to 15 kV	57-1 or 11	55-5	Two 52-2
	57-2 or 12	56-3	Two 52-3 or 4
16 kV to 25 kV	57-2 or 12	56-3	Two 52-3 or 4
	57-3 or 13	56-4	Three 52-3 or 4
26 kV to 35 kV	57-3 or 13	56-4	Three 52-3 or 4
	57-4 or 14	56-5	Four 52-3 or 4

2.9.2 Low-Voltage Line Insulators

Low-voltage line insulators shall comply with ANSI C29.2 and ANSI C29.3 as applicable. Spool insulators for use on low-voltage lines shall be mounted on clevis attachments or secondary racks and shall be not smaller than Class [53-2] [53-3]. For No. 4/0 AWG and larger conductors, Class [53-4] [53-5] shall be used. Suspension insulators on clevis attachments used at dead-ends shall be not smaller than Class 52-1.

2.9.3 Strain Insulators for Guy Wires

Strain insulators for use in insulated guy assemblies shall comply with ANSI C29.4 for porcelain or equivalent fiberglass, and shall have a mechanical strength exceeding the rated breaking strength of the attached guy wire. Insulators shall be not smaller than Class [54-1] [54-2] for lines up to 5 kV, not smaller than Class [54-2] [54-3] for lines of 6 kV to 15 kV, not smaller than Class [54-4] [54-4 with two in tandem] for lines of 16 kV to 25 kV, and not smaller than Class [54-4 with two in tandem] [54-4 with three in tandem] for lines of 26 kV to 35 kV.

2.9.4 Apparatus Insulators

Apparatus insulators shall comply with IEEE C57.19.00, IEEE C57.19.01, ANSI C29.8, and ANSI C29.9 as applicable.

2.10 CROSSARM ASSEMBLIES

2.10.1 Crossarms

Crossarms shall comply with RUS Bull 1728H-701 and shall be solid wood, distribution type, except cross-sectional area with pressure treatment conforming to AWPA C25, and a 6.4 mm (1/4 inch), 1/4 inch, 45 degree chamfer on all top edges. Cross-sectional area minimum dimensions shall be 108.0 mm (4-1/4 inches) 4-1/4 inches in height by 82.6 mm (3-1/4 inches) 3-1/4 inches in depth in accordance with IEEE C2 for Grade B construction. Crossarms shall be 2.4 m (8 feet) 8 feet in length, except that 3.1 m (10 foot) 10 foot crossarms shall be used for crossarm-mounted banked single-phase transformers or elsewhere as indicated. Crossarms shall be machined, chamfered, trimmed, and bored for stud and bolt holes before pressure treatment. Factory drilling shall be provided for pole and brace mounting, for four pin or four vertical line-post insulators, and for four suspension insulators, except where otherwise indicated or required. Drilling shall provide required climbing space and wire clearances. Crossarms shall be straight and free of twists to within 2.5 mm per 304.8 mm (1/10 inch per foot) 1/10 inch per foot of length. Bend or twist shall be in one direction only.

2.11 AUTOMATIC CIRCUIT RECLOSERS

**NOTE: Provide control cabinet location and mounting
details on the drawings.**

Automatic circuit reclosers shall comply with IEEE C37.60 and shall be outdoor oil or vacuum type, complete with devices, attachments, and accessories required for installation and operation and shall be suitable for mounting on a single pole. Each recloser shall have continuous current, minimum tripping current, interrupting current, and making current

ratings and reclosure times as indicated and shall be rated for the voltage and phase of the system in which it is installed. Three-phase lockout shall be provided on three-phase circuits. Reclosers shall include provisions for a sequence of not less than three automatic reclosing operations unless otherwise noted, followed by lockout if the circuit fault persists, and for manual opening, closing, and lockout by use of a hookstick. Operating sequence shall be adjustable for 1, 2, 3, and 4 operations to lockout and for combinations of instantaneous operations followed by time delay openings to secure coordination with other reclosers and fuses in the medium-voltage distribution system. Reclosers shall automatically reset within a definite time interval after a successful reclosure and shall be supplied with devices needed to provide the necessary operating power. Hydraulically-controlled reclosers shall be provided with tank drains and sampling valves. Surge arrester protection shall be provided. [Reclosers shall be equipped with [ground fault tripping] [and] [three-phase current metering] equipment.]

2.12 CAPACITORS

Capacitor equipment shall comply with IEEE Std 18 and shall be of the three-phase, grounded-wye, outdoor type rated for continuous operation and automatically switched. Equipment shall be suitable for mounting on a single pole. Polychlorinated biphenyl and tetrachloroethylene (perchloroethylene) shall not be used as the dielectric. Equipment shall be rated for the system voltage. The indicated kvars shall be automatically switched by [single-step [time switch] [voltage] [current] [kilovar] control] [multiple-step [voltage] [kilovar] control providing the indicated number of steps and switching the indicated kvar]. Necessary transformers shall be provided for sensing circuit variations and for low-voltage control. Oil-immersed switches shall be provided for automatic switching of capacitors, and shall be electrically separate from ungrounded capacitor enclosures and metal frames. Installations shall include one primary fuse cutout and one surge arrester for each ungrounded phase conductor. Fuse link ratings shall be in accordance with the manufacturer's recommendations. Capacitor equipment, except for low-voltage control and primary fuse cutouts, shall be subassembled and coordinated by one manufacturer. Units, including metal pole-mounting supports and hardware, shall be shipped in complete sections ready for connection at the site. Low-voltage equipment shall be socket or cabinet type, mounted on the pole approximately 1.2 m 4 feet above grade, shall be connected with the necessary wiring in conduit to capacitor equipment, and shall be provided with secondary arrester protection against switching surges when recommended by the manufacturer.

2.13 FUSES AND SWITCHES, MEDIUM-VOLTAGE

NOTE: See TM 5-811-1 for guidance on the application of fuses and switches.

A short-circuit study is required to specify ratings. See TM 5-811-14 and UFGS-16475A COORDINATED POWER SYSTEM PROTECTION.

2.13.1 Fuse Cutouts

Medium-voltage fuses and cutouts shall comply with NEMA SG 2 and shall be of the [loadbreak] [nonloadbreak] [enclosed] [open] type construction

[rated [5.2] [7.8] [15] [27] [38] kV and of the [normal] [heavy] [extra-heavy] [ultra-heavy]-duty type] [ratings and types indicated]. Open-link cut-outs are not acceptable. Fuses shall be either indicating or dropout type. Fuse ratings shall be as indicated. Fuse cutouts shall be equipped with mounting brackets suitable for the indicated installations.

2.13.2 Fused Switches

Fused switches shall be single-pole, manual devices with integral power fuses of the dropout type. Fuse ratings shall be as indicated. Each switch shall have a continuous current rating [of [400] [600] amperes rms] [as shown], a momentary asymmetrical current rating of [20] [40] kA rms [as shown] and shall be rated for the voltage of the system in which it is installed.

2.13.3 Nonfused Switches

Nonfused switches shall be single-pole, manual devices with a continuous current rating [of [100] [200] [400] [600] amperes rms] [as shown], a momentary asymmetrical current rating of [20] [40] kA rms [as shown], and shall be rated for the voltage of the system in which it is installed.

2.13.4 Group-Operated Load Interrupter Switches

2.13.4.1 Manually Operated Type (Switch Handle Operated)

Manually operated (switch handle operated) load interrupter switches shall comply with ANSI C37.32 and shall be of the outdoor, manually-operated, three-pole, single-throw type with either tilting or rotating insulators. Switches shall be equipped with interrupters capable of interrupting currents equal to the switch's continuous current rating. Each switch shall be preassembled for the indicated configuration and mounting. Moving contacts shall be of the high-pressure, limited-area type, designed to ensure continuous surface contact. Switches shall be fused or non-fused as indicated. Switches shall be complete with necessary operating mechanisms, handles, and other items required for manual operation from the ground. Switch operating handles shall be located approximately 1.1 meters 3 feet 6 inches above final grade. Insulation of switch operating mechanisms shall include both insulated interphase rod sections and insulated vertical shafts. Each handle shall be provided with a padlock arranged to lock the switch in both the open and the closed position.

2.13.4.2 Remotely Operated Type (Stored-Energy Actuator)

NOTE: SF6 switches are available for nominal voltages of 15 kV through 34.5 kV in 600 ampere continuous and load-break ratings. Delete SCADA equipment and remote telemetry when not required.

Remotely-operated, [air-insulated] [SF6 insulated] load interrupter switches shall be rated in accordance with and comply with the requirements of ANSI C37.32 and shall be of the outdoor, three-pole, [pole-mounted] [crossarm-mounted] type. Interrupter devices shall be [air-insulated] [SF6-insulated, puffer-type] switches capable of interrupting currents equal to the switch continuous current ratings indicated. Switches shall utilize an electric motor-charged, stored-energy (spring-driven) operator to simultaneously trip all phases. A switch-control unit shall be provided

[for push-button operation from the ground] [for push-button operation from the ground and remote switch actuation via telemetry]. The switch-control unit shall be pad-lockable, tamper-resistant, in a NEMA ICS 6, Type [3R] [4] [4X] [4X-SS] enclosure, which is connected to the switch actuator by a shielded control cable. Control power for closing and tripping shall be provided by a battery mounted in the control unit enclosure. The switch control unit shall be provided with a separate 120 volt ac circuit for the battery powered. Power for charging the operator mechanism may be 120 volt ac or battery powered. If operator mechanism charging power is from a battery, capacity shall be provided for a minimum of [_____] [four] sequential opening and closing operation without battery charging. The switch control unit shall be configured for supervisory, control, and data acquisition (SCADA) function, including local and remote operation. Voltage and current sensors shall be provided, one set for each phase, for monitoring of both normal and fault conditions. Switches shall be provided with visual indication of open switch contact for clearance and isolation purposes. Switch mechanisms shall be provided with provisions for grounding of nonenergized metal parts. The switch control unit shall be provided with a switch operations.

2.13.5 Group Operated Load Interrupter Switches

**NOTE: SF6 switches are available for nominal
 voltages of 15 kV through 34.5 kV, in 600 amp
 continuous and load-breaking ratings. Delete SCADA
 equipment and remote telemetry when not required.**

2.13.5.1 Remotely Operated (Stored-Energy Actuator)

Remotely-operated, group-operated, air insulated load interrupter switches shall comply with ANSI C37.32 and shall be of the outdoor, three-pole, pole or crossarm-mounted type. The electrical ratings of remotely-operated, group-operated, gas-insulated load interrupter switches shall be in accordance with the ratings of ANSI C37.32 and shall be of the outdoor, three-pole, [pole-mounted] [crossarm-mounted] type. Interrupting devices shall be [air-insulated switches] [SF6 insulated, puffer-type switches] capable of interrupting currents equal to the switch continuous ratings indicated.

2.13.5.2 Electric-Motor-Charged (Stored-Energy Actuator)

Switches shall utilize an electric-motor-charged, stored-energy (spring-driven) operator to simultaneously trip all phases. A switch-control unit shall be provided [for push-button operation from the ground] [for push-button operation from the ground and remote switch actuation via remote telemetry]. The switch-control unit shall be pad-locked, tamper-resistant, NEMA ICS 6 type [3R] [4] [4X] [4X-SS] enclosure, which is connected to the switch actuator by a shielded control cable. Control power for closing and tripping shall be provided by a battery mounted in the control unit enclosure. The switch-control unit shall be provided with separate 120 volt ac circuit for the battery charger. Power for charging the operator mechanism, may be 120 V ac power or provided from battery power. If operating mechanism charging power is battery, capacity shall be provided for a minimum of [_____] [four] sequential opening and closing operations, without battery charging. The switch-control unit shall be configured for supervisory control, and data acquisition (SCADA) function, including local and remote operation.

Voltage and current sensors shall be provided one set for each phase, for monitoring of both normal and fault conditions. Switches shall be provided with visual indication of open switch contact for clearance and isolation purposes. Switch mechanism shall be provided with provisions for grounding of non-energized metal parts. The switch-control unit shall be provided with a switch operations counter.

2.13.5.3 Pole-Mounted Sectionalizing Switches

Pole-mounted sectionalizing switches shall comply with IEEE C37.63. Sectionalizers shall be coordinated with source side recloser as shown. Ratings at 60 Hz shall be:

Nominal voltage	[_____]
Rated Maximum voltage	[_____]
Rated continuous current	[_____]
Three second short-time current-carrying capacity	[_____]
BIL	[_____]

2.14 ILLUMINATION

**NOTE: Refer to UFGS-16528A, EXTERIOR LIGHTING
INCLUDING SECURITY AND CCTV APPLICATIONS for
illumination requirements.**

2.15 TRANSFORMERS

Transformers shall comply with IEEE C57.12.00 for general requirements and ANSI C57.12.20 for specific requirements for overhead transformers. Overhead distribution transformers shall be of the outdoor type, [mineral-oil-insulated] [less-flammable liquid-insulated with [high molecular-weight-hydrocarbon] [or] [dimethyl silicone] liquid] single-phase or three-phase as indicated and have two separate windings per phase. Transformers shall be provided with necessary auxiliary mounting devices suitable for the indicated installation. Transformers shall have [four 2-1/2 percent] [two 2-1/2 percent] [two 5 percent] rated kVA high-voltage taps [above] [and] [below] rated primary voltage. Transformer installations shall include one primary fuse cutout and one surge arrester for each ungrounded phase conductor. Self-protected transformers are not acceptable. Transformer tanks shall have a standard [gray] [_____] finish.

2.16 SURGE ARRESTERS

Surge arresters shall comply with NEMA LA 1 and IEEE C62.1, ANSI C62.2, and IEEE C62.11, and shall be provided for protection of aerial-to-underground transitions, automatic circuit reclosers, capacitor equipment, group-operated load-interrupter switches, transformers and other indicated equipment. Arresters shall be [station] [intermediate] [distribution] class, rated as shown. [Arresters for use at elevations in excess of 1.8 km (6000 feet) 6000 feet above mean sea level shall be specifically rated for that purpose.] Arresters shall be equipped with mounting brackets suitable for the indicated installations. Arresters shall be of the [valve] [or] [metal-oxide varistor] [or] [combination valve-metal-oxide

varistor] type suitable for outdoor installations.

2.17 VOLTAGE REGULATOR

NOTE: Bypass arresters are normally standard equipment. Incoming line arresters may not be needed. Coordinate with the manufacturer.

Voltage regulators shall comply with IEEE C57.15 and shall be of the outdoor, self-cooled, 55/65 degrees C temperature rise, single-phase type. Windings and the load-tap-changing mechanism shall be mineral-oil-immersed.

When operating under load, a regulator shall provide plus and minus 10 percent automatic voltage regulation in approximately 5/8 percent steps, with 16 steps above and 16 steps below rated voltage. Automatic control equipment shall provide Class 1 accuracy. Bypass surge arresters shall be suitable for [a grounded] [an ungrounded] system and for the associated regulator voltage. [[Station] [Intermediate] class surge arresters shall be mounted next to each incoming line bushing on a regulator tank-mounted bracket and connected to a surge arrester ground pad-mounted on the regulator tank.]

2.17.1 Ratings

Ratings at 60 Hz shall be

Maximum voltage.....[_____]

Basic Insulation Level (BIL).....[_____]

Current.....[_____]

2.17.2 Bypass and Isolation Switches

Switches shall be of the outdoor, stickhook-operated, single-pole, single-throw, vertical-break type suitable for the indicated mounting. Switches shall be of a type designed to provide bypass of a single-phase regulator circuit by an integral sequence which always occurs when each switch is opened or closed. Each opening sequence shall initially bypass the single-phase regulator circuit, then open the input and output circuits, and finally interrupt the exciting current. Opening any single-phase regulator circuit shall not be possible until after the bypass circuit is closed. Ratings at 60 Hz shall be in accordance with IEEE C37.41 and as follows:

Maximum voltage.....[_____]

Nominal voltage class.....[_____]

BIL.....[_____]

Momentary asymmetrical current in the closed position.....[_____]

Momentary asymmetrical current in the bypass position.....[_____]

Continuous and interrupting current.....[_____]

2.17.3 Miscellaneous

Standard accessories and components in accordance with IEEE C57.15 shall be provided. Single-phase units shall be provided with additional components and accessories required by IEEE C57.15 for three-phase units.

2.18 GROUNDING AND BONDING

2.18.1 Driven Ground Rods

Ground rods shall be of [copper-clad steel conforming to UL 467] [zinc-coated steel conforming to ANSI C135.30] [solid stainless steel] not less than [15.9 mm (5/8 inch)] [19.1 mm (3/4 inch)] [5/8] [3/4] inch in diameter by [2.4 meter (8 feet)] [3.1 meter (10 feet)] [8] [10] feet in length of the sectional type driven full length into the earth.

2.18.2 Grounding Conductors

Grounding conductors shall be bare, except where installed in conduit with associated phase conductors. Insulated conductors shall be of the same material as the phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Bare conductors shall be ASTM B 8 soft-drawn unless otherwise indicated. Aluminum is not acceptable.

2.19 PADLOCKS

Padlocks shall comply with Section 08710 DOOR HARDWARE.

2.20 WARNING SIGNS

Warning signs shall be porcelain enameled steel or approved equal. Voltage warning signs shall comply with IEEE C2.

2.21 LIQUID DIELECTRICS

NOTE: Select 2 ppm for Air Force projects.

Liquid dielectrics for transformers, capacitors, reclosers, and other liquid-filled electrical equipment shall be non-polychlorinated biphenyl (PCB) mineral-oil or less-flammable liquid as specified. Nonflammable fluids shall not be used. Tetrachloroethylene (perchloroethylene) and 1, 2, 4 tetrachlorobenzene fluids shall not be used. Liquid dielectrics in retrofitted equipment shall be certified by the manufacturer as having less than [50] [2] parts-per-million (ppm) PCB content. In lieu of the manufacturer's certification, the Contractor may submit a test sample of the dielectric in accordance with ASTM D 923 and have tests performed per ASTM D 4059 at a testing facility approved by the Contracting Officer. Equipment with test results indicating PCB level exceeding [50] [2] ppm shall be replaced.

2.22 FACTORY TESTS

NOTE: Delete tests that are not applicable to the project. Refer to TM 5-811-1. Tests must be justified.

Factory tests shall be performed, as follows, in accordance with the applicable publications and with other requirements of these specifications. The Contracting Officer shall be notified at least [10] [] days before the equipment is ready for testing.

- a. Transformers: Manufacturer's standard [routine] [design] [and] [other] tests in accordance with IEEE C57.12.00.
- b. Transformers rated 200 kVA and above: Reduced full-wave, chopped-wave, and full-wave impulse test on each line [and neutral] terminal, in accordance with IEEE C57.98.
- c. High-Voltage Air Switches: Manufacturer's standard tests in accordance with IEEE C37.34 and IEEE C37.41.
- d. Instrument Current Transformers: Manufacturer's standard tests in accordance with IEEE C57.13.2.
- e. Voltage Regulators: Manufacturer's standard tests in accordance with IEEE C57.15.
- f. High-Voltage Fuses: Manufacturer's standard tests in accordance with IEEE C37.41.
- g. Electric Power Insulators: Manufacturer's standard tests in accordance with ANSI C29.1.
- h. []

2.23 COORDINATED POWER SYSTEM PROTECTION

NOTE: The requirement for the studies in this section depends on the complexity and extent of the power system. Delete this requirement for projects of limited scope; projects having protective devices which are not adjustable or for which coordination is not possible (standard molded case circuit breakers); projects involving simple extension of 600 volt level service to a building or facility from an existing transformer (750 kVA or less), or projects involving simple extension of 600 volt level service to a building or facility from a new transformer (750 kVA or less).

The designer will be responsible for showing and specifying the requirements for fuses, circuit breakers, protective relays, or other protective devices associated with the project. The protective devices should be selected and specified to protect electrical power system conductors or equipment against sustained overloads, in-rush conditions, electrical faults, or other abnormal power system or equipment operating conditions, in accordance with TM 5-811-14, COORDINATED POWER SYSTEM PROTECTION and IEEE Std 242, and IEEE Std 141.

The complexity and extent of coordinated power

system protection depends on the type of buildings or facilities or utilities required, on the load demand of facilities, and on the quantity and types of facilities to be constructed. Facilities having a relatively-low power demand(e.g., 2,500 kVA or less) generally require protection of an incoming aerial distribution line or underground, medium-voltage feeder, low-voltage feeders to individual items of equipment, or to power distribution equipment; and branch circuits. More complex projects such as facilities with generating capacity, large motors, or larger load demands, will require more detailed and extensive coordinated power system protection.

Independent of the type or types of facilities or load demands, the coordinated power system protection will be based on: economics, simplicity, and the electrical power availability dictated by the Using Agency or Service, or by the functional use of the facilities or utilities; required to provided maximum power service with a minimum of power interruptions, and the operating speed of protective devices required to minimize damage to electrical components or items of equipment and to prevent injury to personnel and nuisance tripping.

Unless otherwise approved, a dc power source will be shown and specified to ensure proper closing and tripping of protective devices which require a reliable power source during outage of the normal alternating-current power source.

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for equipment ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and a protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last three years. The Contractor shall provide list of references complete with points of contact, address and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.23.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: [the source bus and extend down to system buses where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses.] [the source bus and extend through the secondary side of transformers for medium voltage distribution.] [the source bus and extend through [outgoing breakers] [outgoing medium voltage feeders, down to the individual protective devices for medium voltage radial taps] [outgoing medium voltage feeders, through the secondary side of transformers] [as indicated] for main electric supply substations.] [the nearest upstream device in the existing source system and extend through the downstream devices at the load end.]

2.23.2 Determination of Facts

**NOTE: Require the Contractor to obtain an available
fault capacity at the power source or provide a
fault capacity on which he is to base his analysis.
Delete the unused option.**

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. [The Contractor shall coordinate with the [commercial power company] [_____] for fault current availability at the site.] [The Contractor shall utilize the fault current availability indicated as a basis for fault current studies.]

2.23.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformer points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformer point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Locations of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.23.4 Fault Current Analysis

The fault current analysis shall be performed in accordance with methods described in IEEE Std 242 and IEEE Std 399. Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedances shall be those proposed. Data shall be documented in the report.

2.23.5 Fault Current Availability

Balanced three-phased fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.23.6 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. Provide a written narrative that describes: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost changes (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.23.7 Study Report

- a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.
- b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.
- c. The report shall document [utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristics curves, current transformer ratios, and relay device numbers and settings;] [and] [existing power system data including time-current characteristics curves and protective device ratings and settings.]
- d. The report shall contain fully coordinated composite time-current characteristic curves for each bus in the system, as required to ensure coordinated power system between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.
- e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Equipment and devices shall be installed and energized in accordance with the manufacturer's published instructions. Circuits installed in conduits or underground and splices and terminations for medium-voltage cable shall conform to the requirements of Section 16375A ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Secondary circuits installed in conduit on poles shall conform to the requirements of .

3.1.1 Conformance to Codes

**NOTE: Plans should indicate where IEEE C2 applies
and where NFPA 70 applies.**

The installation shall comply with the requirements and recommendations of IEEE C2 for [heavy] [medium] [light] loading districts, Grade B construction. No reduction in clearance shall be made. The installation shall also comply with the applicable parts of NFPA 70.

3.1.2 Verification of Dimensions

The Contractor shall become familiar with details of the work, shall verify dimensions in the field, and shall notify the Contracting Officer of any discrepancy before performing any work.

3.1.3 Tree Trimming

NOTE: Indicate on contract drawings where a cleared right-of-way is required. If no cleared right-of-way is required delete the last sentence. Where local practices for tree trimming clearances exceed those shown, follow local practice.

Where lines pass through trees, trees shall be trimmed at least 4.5 m 15 feet [_____] clear on both sides horizontally and below for medium-voltage lines, and [_____] 1.5 m 5 feet clear on both sides horizontally and below for other lines, and no branch shall overhang horizontal clearances. Where trees are indicated to be removed to provide a clear right-of-way, clearing is specified in Section 02231 CLEARING AND GRUBBING.

3.1.4 Disposal of Liquid Dielectrics

PCB-contaminated dielectric shall be marked as PCB and transported to and incinerated by an approved EPA waste disposal facility. The Contractor shall furnish certification of proper disposal. Contaminated dielectric shall not be diluted to lower the level of contamination.

3.2 POLE INSTALLATION

Joint-use electric/roadway-lighting poles for overhead electric and communication lines shall be [wood] [steel] [concrete] poles utilizing [armless] [crossarm] construction. [Cluster-mounted] [Cross-arm mounted] banked single-phase transformer installations shall be provided. [Crossarm construction shall be provided for support of other equipment, except where direct-pole mounting is indicated.] [Pole equipment mounts shall be used for steel and concrete poles and may be used for wood poles rather than crossarm equipment mounts. Detail drawings shall be submitted for approval.] Provision for communication services is required on pole-line construction, except where specifically noted otherwise. A vertical pole space of not less than [600 mm (2 feet)] [2 feet] [_____] shall be reserved at [indicated] [all] locations.

3.2.1 Wood Pole Setting

NOTE: Where specific pole setting depths cannot be given because the type of soil is unknown, use the second bracketed choice; otherwise detail requirements.

Wood Pole Setting: Wood poles shall be set straight and firm. In normal firm ground, minimum pole-setting depths shall be as listed in Table II. In rocky or swampy ground, pole-setting depths shall be decreased or increased [as shown] [respectively in accordance with the local utility's published standards and as approved]. In swampy or soft ground, a bog shoe shall be used where support for a pole is required. Poles in straight runs shall be in a straight line. Curved poles shall be placed with curvatures in the direction of the pole line. Poles shall be set to maintain as even a grade as practicable. When the average ground run is level, consecutive poles shall not vary more than 1.5 m 5 feet in height. When the ground is uneven, poles differing in length shall be kept to a minimum by locating

poles to avoid the highest and lowest ground points. If it becomes necessary to shorten a pole, a piece shall be sawed off the top end and roofed. If any pole is shortened after treatment, the shortened end of the pole shall be given an application of hot preservative. Where poles are set on hilly terrain, along edges of cuts or embankments, or where soil may be washed out, special precautions shall be taken to ensure durable pole foundations, and the setting depth shall be measured from the lower side of the pole. Holes shall be dug large enough to permit proper use of tampers to the full depth of a hole. Earth shall be placed into the hole in 300 mm 6 inch maximum layers, then thoroughly tamped before the next layer is placed. Surplus earth shall be placed around each pole in a conical shape and packed tightly to drain water away from poles.

TABLE II

MINIMUM POLE-SETTING DEPTH (METERS)

Length Overall Meters	Straight Lines	Curves, Corners, and Points of Extra Strain
6.1	1.5	1.5
7.6	1.7	1.7
9.2	1.7	1.7
10.7	1.8	1.8
12.2	1.8	1.8
13.7	2.0	2.1
15.2	2.1	2.3
16.7	2.3	2.5
18.3	2.5	2.6
19.8	2.6	2.6
21.3	2.8	2.9
22.9	2.9	3.0
24.4	3.0	3.2
25.9	3.2	3.3
27.4	3.3	3.5
28.9	3.5	3.7
30.5	3.7	3.8

TABLE II

MINIMUM POLE-SETTING DEPTH (FEET)

Length Overall Feet	Straight Lines	Curves, Corners, and Points of Extra Strain
20	5.0	5.0
25	5.5	5.5
30	5.5	5.5
35	6.0	6.0
40	6.5	6.5
45	6.5	7.0
50	7.0	7.5
55	7.5	8.0
60	8.0	8.5
65	8.5	9.0

TABLE II

MINIMUM POLE-SETTING DEPTH (FEET)

Length Overall Feet	Straight Lines	Curves, Corners, and Points of Extra Strain
70	9.0	9.5
75	9.5	10.0
80	10.0	10.5
85	10.5	11.0
90	11.0	11.5
95	11.5	12.0
100	12.5	12.5

3.2.2 Aluminum, Steel, and Concrete Pole Setting

Poles shall be mounted on cast-in-place or power-installed screw foundations. Concrete poles shall be embedded in accordance with the details shown. Conduit elbows shall be provided for cable entrances into pole interiors.

3.2.2.1 Cast-In-Place Foundations

Concrete foundations, sized as indicated, shall have anchor bolts accurately set in foundations using templates supplied by the pole manufacturer. Concrete work and grouting is specified in Section 03300A CAST-IN-PLACE STRUCTURAL CONCRETE. After the concrete has cured, pole anchor bases shall be set on foundations and leveled by shimming between anchor bases and foundations or by setting anchor bases on leveling nuts and grouting. Poles shall be set plumb. Anchor bolts shall be the manufacturer's standard, and not less than necessary to meet the pole wind loading specified herein and other design requirements.

3.2.2.2 Power-Installed Screw Foundations

Power-installed screw foundations may be used if they have the required strength, mounting-bolt, and top plate dimensions. Screw foundations shall be of at least 6.4 mm (1/4 inch) 1/4 inch thick structural steel conforming to ASTM A 36/A 36M and hot-dip galvanized in accordance with ASTM A 123/A 123M. Conduit slots in screw foundation shafts and top plates shall be marked to indicate orientation. Design calculations indicating adequate strength shall be approved before installation of screw foundation is permitted. Calculations shall be submitted in accordance with the detail drawings portion of paragraph SUBMITTALS.

3.3 CROSSARM MOUNTING

NOTE: Normally flat braces will be specified for 2.4 m (8 foot) crossarms and angle braces for 3.1 m (10 foot) crossarms to agree with REA construction. An angle brace is also required on 2.4 m (8 foot) arms where conductors have a breaking strength of more than 20.0 kN (4500 pounds). Extreme loading conditions may also warrant the extra cost of the stronger angle brace under other circumstances.

Metal crossarm braces will reduce the effective BIL rating of the pole. In high lightning areas specify fiberglass braces.

Consult REA Bulletin 61-10, "Protection of Bald and Golden Eagles from Powerlines." The requirement for wooden crossarm braces should be verified for each state and land area in accordance with the Bald Eagle Protection Act of 1940, (16 U.S.C. 703 et seq.) as amended; Endangered Species Act of 1973 (87 Stat. 1064); and Migratory Bird Treaty of 1918 (16 U.S.C 703 et. seq.) as amended. Potential requirement sources are the Bureau of Land Management, U.S. Department of the Interior, and Federal, State, and Local Land Management or Wildlife Conservation Agencies.

Crossarms shall be bolted to poles with 15.9 mm (5/8 inch) 5/8 inch through-bolts with square washers at each end. Bolts shall extend not less than 3 mm 1/8 inch nor more than 50 mm 2 inches beyond nuts. On single crossarm construction, the bolt head shall be installed on the crossarm side of the pole. [Fiberglass] [Metal] [Wood] crossarm braces shall be provided on crossarms. Flat braces may be provided for 2.4 m (8 foot) 8 foot crossarms and shall be 6.4 by 31.8 mm (1/4 by 1-1/4 inches), 1/4 by 1-1/4 inches, not less than 700 mm (28 inches) 28 inches in length. Flat braces shall be bolted to arms with 9.5 mm (3/8 inch) 3/8 inch carriage bolts with round or square washers between boltheads and crossarms, and secured to poles with 50.8 by 101.6 mm (1/2 by 4 inch) 1/2 by 4 inch lag screws after crossarms are leveled and aligned. Angle braces are required for 3.1 m (10 foot) 10 foot crossarms and shall be 1.5 m (60 inch) 60 inch span by 457.2 mm (18 inch) 18 inch drop formed in one piece from 38.1 by 38.1 by 4.8 mm (1-1/2 by 1-1/2 by 3/16 inch) 1-1/2 by 1-1/2 by 3/16 inch angle. Angle braces shall be bolted to crossarms with 50.8 mm (1/2 inch) 1/2 inch bolts with round or square washers between boltheads and crossarms, and secured to poles with 15.9 mm (5/8 inch) 5/8 inch through-bolts. Double crossarms shall be securely held in position by means of 15.9 mm (5/8 inch) 5/8 inch double-arming bolts. Each double-arming bolt shall be equipped with four nuts and four square washers.

3.3.1 Line Arms and Buck Arms

Line arms and buck arms shall be set at right angles to lines for straight runs and for angles 45 degrees and greater; and line arms shall bisect angles of turns of less than 45 degrees. Dead-end assemblies shall be used for turns where shown. Buckarms shall be installed, as shown, at corners and junction poles. Double crossarms shall be provided at ends of joint use or conflict sections, at dead-ends, and at angles and corners to provide adequate vertical and longitudinal strength. Double crossarms shall be provided at each line-crossing structure and where lines not attached to the same pole cross each other.

3.3.2 Equipment Arms

Equipment arms shall be set parallel or at right angles to lines as required to provide climbing space. Equipment arms shall be located below line construction to provide necessary wire and equipment clearances.

3.4 GUY INSTALLATION

NOTE: Paragraph GUY INSTALLATION. Local practice will determine whether guy strain insulators are provided on guys for wood poles. Normally where guys are not grounded by connection to neutrals or overhead grounding conductors, guys will be insulated (sectionalized) and are considered ungrounded. Some areas require insulators on guys exposed to voltages of less than 22.5 kV, but not for greater voltages unless simultaneously exposed to voltages below 22.5 kV. Strain insulators will prevent a cathodic couple between the anchor and ground rod via the guy and the neutral grounding conductor.

A soil survey should be completed early in the design to properly select the type of anchor.

Guys shall be provided where shown, with loads and strengths as indicated, and wherever conductor tensions are not balanced, such as at angles, corners, and dead-ends. Where a single guy will not provide the required strength, two or more guys shall be provided. Where guys are wrapped around poles, at least two guy hooks shall be provided and pole shims shall be provided where guy tension exceeds 27 kN (6000 pounds). 6000 pounds. Guy clamps 152.4 mm (6 inches) 6 inches in length with three 15.9 mm (5/8 inch) 5/8 inch bolts, or offset-type guy clamps, or approved guy grips shall be provided at each guy terminal. Guy-strain insulators shall be provided in each guy for wood poles. Multiple-helix screw anchors shall be provided in marshy ground; rock anchors shall be installed in rock at right angles to guys, elsewhere anchors shall be of an expanding type, except that power installed screw anchors of equivalent holding power are acceptable. A half-round [yellow] [gray] [_____] polyvinyl, fiberglass, or other suitable plastic guy marker, not less than 2.4 m (8 feet) 8 feet in length, shall be provided at the anchor end of each guy shown, securely clamped to the guy or anchor at the bottom and top of the marker. Holding capacities for down guys shall be based on a lead angle of [45 degrees] [as indicated].

3.5 CONDUCTOR INSTALLATION

3.5.1 Line Conductors

Unless otherwise indicated, conductors shall be installed in accordance with manufacturer's approved tables of sags and tensions. Proper care shall be taken in handling and stringing conductors to avoid abrasions, sharp bends, cuts, kinks, or any possibility of damage to insulation or conductors. Conductors shall be paid out with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible. Bend radius for any insulated conductor shall not be less than the applicable NEMA specification recommendation. Conductors shall not be drawn over rough or rocky ground, nor around sharp bends. When installed by machine power, conductors shall be drawn from a mounted reel through stringing sheaves in straight lines clear of obstructions. Initial sag and tension shall be checked by the Contractor, in accordance with the manufacturer's approved sag and tension charts, within an elapsed time after installation as recommended by the manufacturer.

3.5.2 Connectors and Splices

Connectors and splices shall be mechanically and electrically secure under tension and shall be of the nonbolted compression type. The tensile strength of any splice shall be not less than the rated breaking strength of the conductor. Splice materials, sleeves, fittings, and connectors shall be noncorrosive and shall not adversely affect conductors. Aluminum-composition conductors shall be wire brushed and an oxide inhibitor applied before making a compression connection. Connectors which are factory-filled with an inhibitor are acceptable. Inhibitors and compression tools shall be of types recommended by the connector manufacturer. Primary line apparatus taps shall be by means of hot line clamps attached to compression type bail clamps (stirrups). Low-voltage connectors for copper conductors shall be of the solderless pressure type. Noninsulated connectors shall be smoothly taped to provide a waterproof insulation equivalent to the original insulation, when installed on insulated conductors. On overhead connections of aluminum and copper, the aluminum shall be installed above the copper.

3.5.3 Conductor-To-Insulator Attachments

Conductors shall be attached to insulators by means of clamps, shoes or tie wires, in accordance with the type of insulator. For insulators requiring conductor tie-wire attachments, tie-wire sizes shall be as indicated in TABLE II.

TABLE II

TIE-WIRE REQUIREMENTS

CONDUCTOR Copper (AWG)	TIE WIRE Soft-Drawn Copper (AWG)
6	8
4 and 2	6
1 through 3/0	4
4/0 and larger	2
AAC, AAAC, or ACSR (AWG)	AAAC OR AAC (AWG)
Any size	6 or 4

3.5.4 Armor Rods

Armor rods shall be provided for AAC, AAAC, and ACSR conductors. Armor rods shall be installed at supports, except armor rods will not be required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used. Lengths and methods of fastening armor rods shall be in accordance with the manufacturer's recommendations. For span lengths of less than 61 m, 200 feet, flat aluminum armor rods may be used. Flat armor rods, not less than 762.0 micrometers by 6.4 mm (0.03 by 0.25 inch) 0.03 by 0.25 inch shall be used on No. 1 AWG AAC and AAAC and smaller conductors and on No. 5 AWG ACSR and smaller conductors. On larger sizes, flat armor rods shall be not less than 1.3 by 7.6 mm (0.05 by 0.30 inches). 0.05 by 0.30 inches. For span lengths of 61 m 200 feet or more, preformed round armor rods shall be used.

3.5.5 Medium-Voltage Insulated Cables

NOTE: Provide storm guying in extreme wind loading districts as defined by IEEE C2 and elsewhere when more than normal conductor loading occurs.

Medium-voltage cable messengers shall be attached to poles with clamps providing a strength exceeding the required messenger strength and with not less than 15.9 mm (5/8 inch) 5/8 inch through-bolts. Messengers shall be dead-ended, grounded, [and] [and storm and] line-guyed at corners and dead-ends, and at intervals not exceeding 305 m 1000 feet along straight runs.

3.5.6 Low-Voltage Insulated Cables

NOTE: Due to both space requirements and the unattractive appearance, line conductors on secondary racks will be limited to special circumstances.

Low-voltage cables shall be supported on clevis fittings using spool insulators. Dead-end clevis fittings and suspension insulators shall be provided where required for adequate strength. Dead-end construction shall provide a strength exceeding the rated breaking strength of the neutral messenger. Clevis attachments shall be provided with not less than 15.9 mm (5/8 inch) 5/8 inch through-bolts. Secondary racks may be used when installed on wood poles and where the span length does not exceed 61 m. 200 feet. Secondary racks shall be two-, three-, or four-wire, complete with spool insulators. Racks shall meet strength and deflection requirements for heavy-duty steel racks, and shall be either galvanized steel or aluminum alloy. Tops of insulator saddles shall be rounded and smooth to avoid damage to conductor insulation. Each insulator shall be held in place with a 15.9 mm (5/8 inch) 5/8 inch button-head bolt equipped with a nonferrous cotter pin, or equivalent, at the bottom. Racks for dead-ending four No. 4/0 AWG or four larger conductors shall be attached to poles with three 15.9 mm (5/8 inch) 5/8 inch through-bolts. Other secondary racks shall be attached to poles with at least two 15.9 mm (5/8 inch) 5/8 inch through-bolts. Minimum vertical spacing between conductors shall not be less than 200 mm. 8 inches.

3.6 TRANSFORMER INSTALLATION

NOTE: Specify phase sequence in accordance with the local practice.

Transformers shall be carefully installed so as not to scratch finishes or damage bushings. Transformers shall be installed in accordance with the manufacturer's instructions. After installation, surfaces shall be inspected and scratches shall be touched up with a finish provided by the transformer manufacturer for this purpose. Three-phase transformer installations shall be installed with [_____] phase sequence. Primary taps shall be set at [_____].

3.7 CONNECTIONS TO UTILITY LINES

NOTE: This paragraph will be further developed to suit the conditions of any connections required to the serving utility's lines.

The Contractor shall coordinate the work with the Contracting Officer and shall provide for final connections to the [utility] [installation] electric lines.

3.8 CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS

Connections between aerial and underground systems shall be made as shown. Underground cables shall be extended up poles in [guards] [conduit] to cable terminations. Conduits shall be secured to poles by [conduit supports] [two-hole galvanized steel pipe straps] spaced not more than 3 m 10 feet apart and with one support not more than 300 mm 12 inches from any bend or termination. Cables shall be supported by devices separate from the conduit or guard, near their point of exit from the riser conduit or guard. Cables guards shall be secured in accordance with the manufacturers published procedure. Risers shall be equipped with bushings to protect cables. Capnut potheads shall be used to terminate medium-voltage multiple-conductor cable.

3.9 CONNECTIONS TO BUILDINGS

3.9.1 Aerial Services

Connections to buildings shall be made at approximately the point indicated and shall be connected to the service entrance conductors. Supports at buildings shall be adequate to withstand required pulls; supports shall not be rated less than 4450 N (1000 pounds). 1000 pounds. Drip loops shall be formed on conductors at entrances to buildings, cabinets, or conduits. Service-entrance conduits with termination fittings and conductors within the building, including sufficient slack for connection to aerial service cables, shall conform to the requirements of Section 16402 INTERIOR DISTRIBUTION SYSTEM.

3.9.2 Underground Services

Connections to buildings shall be made at the point indicated and shall be terminated at the service entrance equipment terminals. Cable pulling shall be in accordance with Section 16375A, ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Service entrance conduits with termination fittings and conductors within the building shall conform to the requirements of Section 16402 INTERIOR DISTRIBUTION SYSTEM.

3.10 GROUNDING

NOTE: The designer will specify the grounding configuration and the number and type of electrodes required. See TM 5-811-1 for guidance. Coordinate with NFPA 70 and IEEE C2.

Some state codes do not permit grounding of metallic items mounted on wood poles above a certain height.

In some states it is standard practice to ground all noncurrent-carrying metal parts on all poles. Grounding all hardware on a pole reduces the natural BIL levels afforded with wood crossarm construction. While reduced BIL levels in high lightning incidence areas may result in more insulation flashovers, bonding all hardware will result in fewer pole fires.

Noncurrent-carrying metal parts of equipment and conductor assemblies, such as luminaires, medium-voltage cable terminations and messengers, metal poles, operating mechanisms of pole top switches, panel enclosures, transformers, capacitors, recloser frames (cases) and other noncurrent-carrying metal items shall be grounded. Additional grounding of equipment, neutral, and surge arrester grounding systems shall be installed at poles where indicated.

3.10.1 Grounding Electrodes

NOTE: Modify and/or delete paragraphs in accordance with project requirements.

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

Grounding electrodes shall be installed as follows:

- a. Driven rod electrodes - Unless otherwise indicated, ground rods shall be located approximately 900 mm 3 feet out from base of the pole and shall be driven into the earth until the tops of the rods are approximately 300 mm 1 foot below finished grade. Multiple rods shall be evenly spaced at least 3 m 10 feet apart and connected together 600 mm 2 feet below grade with a minimum No. 6 bare copper conductor.
- b. Pole butt electrodes - Pole butt electrodes shall be installed where indicated, except that this method shall not be the sole grounding electrode at transformer locations. The pole butt electrode shall consist of a coil of at least 4 m 12 feet of minimum No. 6 bare copper conductor stapled to the butt of the pole.
- c. Plate electrodes - Plate electrodes shall be installed in accordance with the manufacturer's instructions and IEEE C2 and NFPA 70.
- d. Ground Resistance - The maximum resistance of a [driven ground rod] [pole butt electrode] [plate electrode] shall not exceed 25 ohms under normally dry conditions. Whenever the required ground resistance is not met, provide additional electrodes

[interconnected with grounding conductors] [as indicated], to achieve the specified ground resistance. The additional electrodes will be [up to three, [2.4 m (8 feet) 8 feet] [3 m (10 feet) 10 feet] rods spaced a minimum of 3 m (10 feet) 10 feet apart], [a single extension-type rod, 15.9 mm (5/8 inch) 5/8 inch 19.1 mm (3/4 inch) 3/4 inch diameter, up to 9.1 m (30 feet) 30 feet long, [driven perpendicular to grade] [coupled and driven with the first rod]]. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately. Connections below grade shall be fusion welded. Connections above grade shall be fusion welded or shall use UL 467 approved connectors.

3.10.2 Grounding and Bonding Connections

Connections above grade shall be made by the fusion-welding process or with bolted solderless connectors in compliance with UL 467, and those below grade shall be made by a fusion-welding process. Where grounding conductors are connected to aluminum-composition conductors, specially treated or lined copper-to-aluminum connectors suitable for this purpose shall be used.

3.10.3 Grounding Electrode Conductors

NOTE: Provide a "detail."

On multi-grounded circuits, as defined in IEEE C2, provide a single continuous vertical grounding electrode conductor. Neutrals, surge arresters, and equipment grounding conductors shall be bonded to this conductor. For single grounded or ungrounded systems, provide a grounding conductor for the surge arrester and equipment grounding conductors and a separate grounding conductor for the secondary neutrals. Grounding electrode conductors shall be sized as shown. Secondary system neutral conductors shall be connected directly to the transformer neutral bushings, then connected with a neutral bonding jumper between the transformer neutral bushing and the vertical grounding electrode conductor, as shown. Grounding electrode conductors shall be stapled to wood poles at intervals not exceeding 600 mm. 2 feet. On metal poles, a preformed galvanized steel strap, 15.9 mm (5/8 inch) 5/8 inch wide by 0.853 (22 gauge) 22 gauge minimum by length, secured by a preformed locking method standard with the manufacturer, shall be used to support a grounding electrode conductor installation on the pole and spaced at intervals not exceeding 1.5 m 5 feet with one band not more than 75 mm 3 inches from each end of the vertical grounding electrode conductor. Bends greater than 45 degrees in grounding electrode conductor are not permitted.

3.11 FIELD TESTING

NOTE: Select types to suit project conditions and delete all others. Delete all paragraphs not applicable. Tests must be justified.

3.11.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer [_____] days prior to conducting tests. The Contractor shall furnish materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field reports will be signed and dated by the Contractor.

3.11.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.11.3 Ground-Resistance Tests

The resistance of [each grounding electrode system] [each pole ground] [_____] shall be measured using the fall-of-potential method defined in IEEE Std 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes shall be provided.

3.11.4 Medium-Voltage Preassembled Cable Test

NOTE: If the installation is tapping a new feeder to an existing feeder using a "T" splice, modify the paragraph to indicate that when existing cable cannot be readily disconnected, the system should only be tested to the lower (after installation) voltage. Delete the test if no cable is installed in the project.

After installation, prior to connection to an existing system, and before the operating test, the medium-voltage preassembled cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors at one terminal and connecting grounds or metallic shieldings or sheaths of the cable at the other terminal for each test. Prior to the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 74 for the particular type of cable installed, and shall not exceed the recommendations of IEEE Std 404 for cable joints unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other

connections, the Contractor shall make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

3.11.5 Sag and Tension Test

The Contracting Officer shall be given prior notice of the time schedule for stringing conductors or cables serving overhead medium-voltage circuits and reserves the right to witness the procedures used for ascertaining that initial stringing sags and tensions are in compliance with requirements for the applicable loading district and cable weight.

3.11.6 Low-Voltage Cable Test

NOTE: The insulation resistance test (dielectric test) value is based on the recommendation contained in IEEE Std 525. Delete the cable test if no low voltage cables are in the project.

For underground secondary or service laterals from overhead lines, the low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations of conductors in the same trench, duct, or cable, with other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

$R \text{ in megohms} = (\text{rated voltage in kV} + 1) \times 304,800 / (\text{length of cable in meters})$

$R \text{ in megohms} = (\text{rated voltage in kV} + 1) \times 1000 / (\text{length of cable in feet})$

Each cable failing this test shall be repaired or replaced. The repaired cable shall then be retested until failures have been eliminated.

3.11.7 Liquid-Filled Transformer Tests

The following field tests shall be performed on liquid-filled transformers [[_____] kVA and above]. Pass-fail criteria shall be in accordance with the transformer manufacturer's specifications.

- a. Insulation resistance test phase-to-ground.
- b. Turns ratio test.
- c. Correct phase sequence.
- d. [_____]

3.11.8 Pre-Energization Services

The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to insure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare

and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment and to ensure that packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services shall be provided, but are not limited to, are the following:

Automatic circuit reclosers.

Capacitors.

Switches.

Transformers.

3.11.9 Operating Tests

After the installation is completed, and at such time as the Contracting Officer may direct, the Contractor shall conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the specified requirements. An operating test report shall be submitted in accordance with paragraph SUBMITTALS.

3.12 MANUFACTURER'S FIELD SERVICE

NOTE: Delete if not required.

3.12.1 Onsite Training

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of [_____] hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The course instruction shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations. A [_____] [BETA] [VHS] format video tape of the entire training session shall be submitted.

3.12.2 Installation Engineer

After delivery of the equipment, the Contractor shall furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of the equipment, assist in the performance of the onsite tests, initial operation, and instruct personnel as to the operational and maintenance features of the equipment.

3.13 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation,

material or operation have been corrected.

-- End of Section --