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DEPARTMENT OF THE NAVY
ATLANTIC DIVISION/EFAMED
NAVAL FACILITIES
ENGINEERING COMMAND
GUIDE SPECIFICATION

IGS-16364 (April 2004)

Based on UFGS-16360N (09/99)

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SECTION IGS-16364

HIGH VOLTAGE/LOW VOLTAGE PREFABRICATED SUBSTATIONS
04/04

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NOTE: This guide specification is issued by the Atlantic Division, Naval Facilities Engineering Command for regional use in Italy. This guide specification covers the requirements for high voltage/low voltage prefabricated substations (also defined as unit substations), in the medium voltage range of 5 kV to 35 kV for both indoor and outdoor applications. Pad-mounted transformers are specified in Section 16272, "Pad-Mounted Transformers", and are to be specified only at European Activities at which pad mounted transformers are an accepted practice. Pole-mounted distribution transformers are specified in Section 16301, "Overhead Transmission and Distribution", and are to be specified only at European Activities at which pole mounted transformers are an accepted practice. Separately mounted high voltage switchgear and power transformers are specified in Section 16363, "High Voltage Switchgear and Power Transformers". Separately mounted low voltage switchgear and controlgear is specified in Section 16430, "Low Voltage Switchgear and Controlgear".

Comments and suggestions on this specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents and their telephone numbers is located on the Spec Support page on the LANTDIV website.

Use of electronic communication is encouraged.

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

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NOTE: The following information shall be indicated on the project drawings or specified in the project

specifications:

1. Single-line diagram showing buses and interrupting devices; current transformers and voltage transformers (potential transformers) with ratings; instruments and meters required; and description of instruments and meters.

2. Interrupting capacities.

3. Location and space available for the unit substation and all auxiliary equipment.

4. Drawing showing desired arrangement of the unit substation and all auxiliary equipment.

5. Grounding system plan and details.

6. Type and number of cables, and size of conductors for each power circuit, point of entry (top or bottom), and method of power cable termination (clamp-type terminals or terminators).

7. Minimum and maximum overall dimensions of shipping section which can be handled and installed at destination.

8. Special conditions, such as altitude, temperature and humidity, exposure to fumes, vapors, dust, and gases; and seismic requirements.

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PART 1 GENERAL

1.1 REFERENCES

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NOTE: Maximize the use of European technical/construction standards. Do not reference host nation standards that duplicate an available European standard. However, the designer is responsible for determining if there are any specific host nation standards that must be referenced. Consult with the project's Activity to determine their requirements and standards.

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

ITALIAN ELECTROTECHNICAL COMMITTEE (CEI)

CEI 7-6 (1997); Requirements for Checking Hot

	Galvanizing by Immersion on Ferrous Components Used in Lines and Electrical Installations
CEI 11-1	(1999; V1 2000; Errata Corrige 2001) Power Installations Exceeding 1 kV a.c.
CEI 14-8	(1999; V1 2002) Dry Type Power Transformers
CEI 14-13	(1998; V1 1998) Three Phase Oil-Immersed Distribution Transformers 50 Hz, from 50 kVA to 2500 kVA, with Highest Voltage for Equipment not Exceeding 36 kV. Part 1: General Requirements and Requirements for Transformers with Highest Voltage for Equipment not Exceeding 24 kV
CEI 17-1	(1998; V1 1999) High-Voltage Alternating-Current Circuit-Breakers
CEI 64-8	(2003) Electrical Installations of Buildings
CEI UNI EN 45510-2-3	(2000) Guide for Procurement of Power Station Equipment. Part 2-3: Electrical Equipment. Stationary Batteries and Chargers
CEI EN 60044-1	(2000; V1 2001, V2 2003) Instrument Transformers Part 1: Current Transformers
CEI EN 60044-2	(2001; V1 2003) Instrument Transformers - Part 2: Inductive Voltage Transformers
CEI EN 60060-2	(1998; V1 2000) High-Voltage Test Techniques Part 2: Measuring Systems
CEI EN 60076-1	(1998; V1 2002) Power Transformers Part 1: General
CEI EN 60076-2	(1998) Power Transformers Part 2: Temperature Rise
CEI EN 60076-3	(2002) Power Transformers Part 3: Insulation Levels, Dielectric Test, and External Clearances in Air
CEI EN 60076-4	(2003) Power Transformers Part 4: Guide to Lighting Impulse and Switching Impulse Testing - Power Transformers and Reactors
CEI EN 60076-5	(2001) Power Transformers Part 5: Ability to Withstand Short Circuit

CEI EN 60076-10	(2002) Power Transformers Part 10: Determination of Sound Levels
CEI EN 60143-1	(1998) Series Capacitors For Power Systems Part 1: General - Performance, Testing and Rating - Safety Requirements - Guide Installation
CEI EN 60143-2	(1998) Series Capacitors For Power Systems Part 2: Protective Equipment For Series Capacitor Banks
CEI EN 60143-3	(1999) Series Capacitors For Power Systems Part 3: Internal Fuses
CEI EN 60265-1	(2000) High-Voltage Switches Part 1: Switches for Rated Voltages Above 1 kV and Less Than 52 kV
CEI EN 60269-1	(2000) Low-Voltage Fuses Part 1: General Requirements
CEI EN 60298	(1998; Amend 2000) AC Metal-Enclosed Switchgear and Controlgear for Rated Voltages Above 1 kV and Up To and Including 52 kV
CEI EN 60439-1	(2000) Low-Voltage Switchgear and Controlgear Assemblies Part 1: Type-Tested and Partially Type-Tested Assemblies
CEI EN 60439-2	(2000; EC 2001) Low-Voltage Switchgear and Controlgear Assemblies Part 2: Particular Requirements For Busbar Trunking Systems (Busways)
CEI EN 60529	(1997; Amend 2000) Degrees of Protection Provided By Enclosures (IP Code)
CEI EN 60694	(1997; Amend 2002) Common Specifications for High-Voltage Switchgear and Controlgear Standards
CEI EN 60831-1	(1997; Amend 2003) Shunt Power Capacitors of the Self-Healing Type for a.c. Systems Having a Rated Voltage Up To and Including 1 kV Part 1: General - Performance, Testing and Rating Safety Requirements - Guide for Installation and Operation
CEI EN 60831-2	(1997) Shunt Power Capacitors of the Self-healing Type for A.C. Systems having a Rated Voltage up to and Including 1 kV

	Part 2: Aging Test, Self-Healing Test, and Destruction Test
CEI EN 60896-2	(1997) Stationary Lead-Acid Batteries General Requirements and Methods of Test Part 2: Valve Regulated Types
CEI EN 60934	(2002) Circuit Breakers for Equipment (CBE)
CEI EN 60947-1	(2000; Amend 2002) Low-Voltage Switchgear and Controlgear - Part 1: General Rules
CEI EN 60947-2	(1998; A1 1999, EC 2001, A2 2002) Low-Voltage Switchgear and Controlgear - Part 2: Circuit Breakers
CEI EN 60947-4-1	(2002) Low-Voltage Switchgear and Controlgear Part 4-1: Contactors and Motor-Starters - Electromechanical Contactors and Motor-Starters
CEI EN 60947-5-1	(1998; Amend 2000, EC 2001) Low-Voltage Switchgear and Controlgear Part 5-1: Control Circuit Devices and Switching Elements Electromechanical Control Circuit Devices
CEI EN 60947-7-1	(1998; Amend 2000) Low-Voltage Switchgear and Controlgear. Part 7: Ancillary Equipment. Section One: Terminal Blocks for Copper Conductors
CEI EN 61010-1	(2001) Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use Part 1: General Requirements
CEI EN 61330	(1997) High-Voltage/Low-Voltage Prefabricated Substations
CEI EN 62271-102	(2003) High-Voltage Switchgear and Controlgear Part 102: High-Voltage Alternating Current Disconnectors and Earthing Switches

ITALIAN LAWS AND NORMS

D.P.R. 547	(27 April, 1955) Norms for Accident Prevention on Worksite
LAW 46	(5 March, 1990) Safety Norms for Technological Systems

ITALIAN NATIONAL ASSOCIATION FOR UNIFICATION OF STANDARDS (UNI)

UNI EN 10088-1	(1997) Stainless Steels Part 1: List of Stainless Steels

1.2 RELATED REQUIREMENTS

Section 16050, "Basic Electrical Materials and Methods" and Section 16081, "Apparatus Inspection and Testing" apply to this section, with the additions and modifications specified herein. Materials not considered to be high voltage/low voltage prefabricated substation material or components are specified in Section 16303, "Underground Electrical Work" and Section 16402, "Interior Distribution System".

1.3 DEFINITIONS

a. Host Nation: The host nation is the nation in which the construction project is located and in which the construction work will actually occur.

b. High voltage/low voltage prefabricated substations (also identified as "unit substations") are integrally designed and integrally constructed assemblies consisting of three basic subassemblies: (1) high voltage section including primary overcurrent protection features and primary disconnection features; (2) power transformer section; and (3) low voltage distribution and control section. The entire assembly shall be a standard catalog product of a single electrical power equipment manufacturer or a qualified fabricator who is regularly engaged in the design, sales and services of electrical power equipment assemblies. In the text of this specification section, the words "high voltage/low voltage prefabricated substation" and "unit substation" are used interchangeably and have the same meaning.

c. Projects in Italy must comply with Italian Laws and Norms, D.P.R. 547 (1955) Norms for Accident Prevention on Worksite; LAW 46, (1990) Safety Requirements for Electrical System.

1.4 SUBMITTALS

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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.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. Submit the following in accordance with Section 01330, "Submittal Procedures".

SD-02 Shop Drawings

Unit substation drawings; G

Overall dimensions, front, sectional view; G

[DC power system drawings; G]

[Alarm system drawings; G]

[Automatic power factor compensating unit drawings; G]

SD-03 Product Data

Unit substation; G

[DC power system; G]

[Alarm system; G]

[Automatic power factor compensating unit; G]

[SD-05 Design Data

Battery power calculations; G

] SD-06 Test Reports

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NOTE: Delete "ground resistance test reports" and the associated subparagraph if such tests are also required in another section such as Section 16303, "Underground Electrical Work", or Section 16402, "Interior Distribution System". Define ground system tests only once in the specifications. All associated sections are to reference the section that defines the ground system test requirements. It is preferred to define ground system tests in Section 16303.

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Acceptance checks and tests; G

[Ground resistance tests; G]

SD-07 Certificates

Manufacturer's factory test schedule; G

[Schedule of power relay settings and calibrations; G]

[Request for final power relay settings; G]

[Motor and equipment load coordination; G]

SD-08 Manufacturer's Instructions

Unit substation; G

[DC power system; G]

[Automatic power factor compensating unit; G]

SD-09 Manufacturer's Field Reports

High voltage[switches][switch assembly] design tests; G

High voltage circuit breaker design tests; G

High voltage[switches][switch assembly] production tests; G

High voltage circuit breaker production tests; G

Transformer design tests (liquid insulated); G

Transformer routine and other tests (liquid insulated); G

Transformer design tests (dry type); G

Transformer routine and other tests (dry type); G

Low voltage switchgear design tests; G

Low voltage switchgear production tests; G

SD-10 Operation and Maintenance Data

Unit substation; G, Data Package 5

[DC power system; G, Data Package 5]

[Alarm system; G, Data Package 5]

[Automatic power factor compensating unit; G, Data Package 5]

1.5 QUALITY ASSURANCE

1.5.1 Unit Substation Drawings

Furnish drawings that include, but are not limited to, the following:

a. Overall dimensions, front, sectional view, weights, top and bottom

views of each major component. Identify all auxiliary equipment, devices and components.

b. Ampere ratings of bus bars.

c. Maximum short-circuit bracing.

d. Equipment type and ratings (continuous and load break rating) of all high voltage and low voltage overcurrent protection equipment.

e. Ratings and sizes of lugs.

[f. Provision for future extension.]

g. Elementary diagrams and wiring diagrams with terminals identified and labeled to correspond to the designations on the equipment. Diagrams shall indicate prewired interconnections between items of equipment and the interconnection between the items. This shall include items that are mounted internal with the substation and items that are mounted external to the substation (that is, field wiring). Provide individual drawings of each terminal board.

h. One-line diagram including high voltage equipment, power transformer, low voltage distribution equipment, voltage and current transformers, protective power relays and associated devices, metering equipment, fuses, surge arresters, and so forth.

i. Manufacturer's original published time-current curves, not reproduced copies, (on full size logarithmic paper) of[fuses][and][overcurrent relays] to ensure that protection and coordination are achieved.

j. Nameplate data.

[1.5.2 DC Power System Drawings

Furnish drawings that include, but are not limited to, the following:

a. Overall dimensions, plan view and front view, including the identification of all auxiliary equipment, devices and components.

b. Ampere ratings of bus bars, circuit breakers and fuses.

c. Circuit breaker type and ratings.

d. Elementary diagrams and wiring diagrams with terminals identified and labeled to correspond to the designations on the equipment. Diagrams shall indicate prewired interconnections between items of equipment and the interconnection between the items.

e. Nameplate data.

][1.5.3 Alarm System Drawings

Furnish drawings that include, but are not limited to, the following:

a. Overall dimensions with front and interior views of the panel including the identification of all auxiliary equipment, devices and components.

b. Elementary diagrams and wiring diagrams with terminals identified and labeled to correspond to the designations on the equipment. Diagrams shall indicate prewired interconnections between items of equipment and the interconnecting between the items. This shall include items that are mounted internal with the alarm panel and items that are mounted external to the alarm panel (that is, field wiring). Provide individual drawings of each terminal board.

][1.5.4 Automatic Power Factor Compensating Unit Drawings

Furnish drawings that include, but are not limited to, the following:

a. Overall dimensions, plan view and front view, including the identification of all auxiliary equipment, devices and components.

b. Ampere ratings of bus bars, circuit breakers and fuses.

c. Circuit breaker type and ratings.

d. Elementary diagrams and wiring diagrams with terminals identified and labeled to correspond to the designations on the equipment. Diagrams shall indicate prewired interconnections between items of equipment and the interconnection between the items.

e. Nameplate data.

]1.5.5 Product Data

Each submittal shall include data on[circuit breakers,][switches,][fuses][protective power relays and associated devices,] power transformers,[meters, instrument transformers,][surge arresters,] and all associated accessories. Submittals shall show sectional views of cubicles. Provide manufacturer's instruction manuals for all[protective power relays and associated devices][and][metering equipment], including instructions of how to set and operate all components.

[1.5.6 Battery Power Calculations

Submit capacity calculations for battery charger and batteries. Calculation shall verify that battery capacity exceeds station DC power requirements.

]1.5.7 Manufacturer's Instructions

Submit the manufacturer's installation instruction manuals within 30 days after receiving approved shop drawings and product data.

1.5.8 Acceptance Checks and Tests

Submit report of acceptance test results as specified by paragraph entitled

"Field Quality Control".

[1.5.9 Ground Resistance Tests

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NOTE: Delete "ground resistance test reports" and the associated subparagraph if such tests are also required in another section such as Section 16303, "Underground Electrical Work", or Section 16402, "Interior Distribution System". Define ground system tests only once in the specifications. All associated sections are to reference the section that defines the ground system test requirements. It is preferred to define ground system tests in Section 16303.
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Upon completion and before energizing electrical equipment, submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil condition at the time the measurements were made.

]1.5.10 Manufacturer's Factory Test Schedule

The Government reserves the right to witness all factory tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 45 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

1. The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

2. The accuracy shall be directly traceable to a recognized European institute of standards and technology.

3. Instrument calibration frequency schedule shall not exceed 12 months for both test floor instruments and leased specialty equipment.

4. Dated calibration labels shall be visible on all test equipment.

5. Calibrating standard shall be of higher accuracy than that of the instrument tested.

6. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

[1.5.11 Schedule of Power Relay Settings and Calibrations

Provide a Schedule of Power Relay Settings and Calibrations. The Contractors hall submit recommended settings of all protective power relays and associated devices. These values shall be based upon the recommendations of the manufacturer of the respective power equipment (high voltage switchgear/circuit breaker). These values are for comparison purposes relative to the intent of the original design. Include in the schedule the anticipated dates when equipment requiring coordination and protection will be installed, the anticipated date when the Contractor will request the list of final settings, and the anticipated date when the manufacturer's technical representative will perform settings and calibrate equipment.

][1.5.12 Request for Final Power Relay Settings

a. Final settings of the protective relays and associated devices will be provided by the Contractor in accordance with the relay setting coordination study provided by the Government to achieve protection and coordination via relays and protective devices. Submit a request for power relay settings [45][____] days in advance of the date that settings will be needed, to allow the Contracting Officer sufficient time to obtain the final setting values from the responsible representatives.

b. The equipment requiring protection and coordination shall be installed prior to making this request.

c. Include approved shop drawings, manufacturer's instructions to set the protective devices, and manufacturer's time-current curves.

][1.5.13 Motor and Equipment Load Coordination

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NOTE: Include this paragraph if the low voltage switchgear section has motor control features or serves motorized equipment.

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The Contractor shall submit a certificate that states the final selection of all electrical devices, components, overcurrent protection devices, and so forth are based upon the actual size of motors and electrified equipment to be provided. Submit a list of all motors/equipment and define all pertinent electrical data including horsepower rating, power rating, voltage including number of phases, full load amperage, maximum overcurrent protection rating, minimum circuit ampacity, and the amperage of the circuit breakers and fuses to be provided.

]1.5.14 Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section 01781, "Operation and Maintenance Data." In addition, see paragraph titled "Additions to Operation and Maintenance Manuals".

1.5.15 Additions to Operation and Maintenance Manuals

In addition to requirements of Data Package 5, include the following on the actual equipment provided.

a. An instruction manual with pertinent items and information highlighted

b. An outline drawing, including front view and sectional views with items and devices identified

c. Prices for spare parts and supply list

d. Routine and field acceptance test reports

e. Time-current-characteristic (T-C-C) curves of breakers[and fuses]

f. Actual nameplate diagram

g. Date of purchase

[h. Information on[protective power relays and associated protective devices][and][metering equipment] including the manufacturer's operational instruction manual.]

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

2.1.1 CE Marking and Display

Equipment, materials, components, assemblies and so forth which are subject to European Union (EU) economic directives shall have an approved Declaration of Conformity as demonstrated by an authorized display of the CE Mark (Conformite Europeenee Mark). The CE Mark logo shall be placed on the product, the product literature, and/or packaging as required by the respective EU directive, or directives.

2.1.2 Factory Assembly

The unit substation and all subassemblies shall be factory assembled by an electrical manufacturer or fabricator who is regularly engaged in the dedicated construction of high voltage electrical equipment and assemblies. Switchgear assembly by the Contractor in the field or in his shop shall not be acceptable. This includes the assembly of the low voltage switchgear and controlgear.

2.2 SOURCE MANUFACTURERS

The following manufacturers provide low voltage switchgear and controlgear materials that generally meet the requirements of the specifications:

a. ABB S.p.A.
Via Luciano Lama, 33
20099 Sesto S. Giovanni (MI)
Tel. (39) 02/2414.1
Fax (39) 02/24142330
www.abb.com/it

b. Schneider Electric S.p.A.
Direzione Generale
Viale Colleoni, 7 - Palazzo Sirio
20041 Agrate Brianza (Mi)
Italia
tel: (39) 39 655 8111
fax: (39) 39 605 6237
www.schneiderelectric.it

c. Gemmo Impianti S.p.A.
36057 Arcugnano
(Vicenza), Italy
Viale dell Industria, 2
Tel. (39) 0444959595
Fax (39) 0444961551
www.gemmo.com

2.3 PRODUCT COORDINATION

Products and materials not considered to be unit substations and related accessories are specified in Section 16303, "Underground Electrical Work" and Section 16402, "Interior Distribution System."

2.4 UNIT SUBSTATION

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NOTE: Indicate and specify the type of unit substation required for the project. This is especially in reference to the transformer type. This includes: (1) interior installation versus exterior installation; and (2) liquid insulated type transformer versus dry type transformer. Selection and design shall be based upon the following:

1. Outdoor mounted substations shall only be specified where specifically required by the Activity.

2. Consult with the Activity regarding preferences for transformer type (liquid insulated versus dry type). The designer must be aware of environmental requirements of the host nation. Oil insulated transformers may require spill containment systems

that are expensive and require significant space and underground burial.

3. As a result of the environmental issues, the Aviano Air Base (Aviano, Italy) requires dry type transformers that must be mounted indoors.

4. If liquid insulated transformers are specified, then specify mineral oil insulation wherever possible. Less-flammable liquid insulated transformers may be used as approved by the Activity and when installed in accordance with the host nation's safety and environmental requirements. For interior liquid insulated transformers comply with all requirements defined in MIL-HDBK-1008, "Fire Protection for Facilities Engineering, Design, and Construction" and with the host nation's safety and environmental requirements.

5. If it is anticipated that future load requirements will necessitate increasing the capacity of the transformer, the specification for the transformer should require the provision of components and brackets for future forced air cooling and mechanical circulation for the coolant fluid (if liquid insulated).

6. If forced-air-cooling is immediately specified, define such requirements on the drawings, provide associated details, and define the operational control features.

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CEI EN 61330. Unit substations shall be integrally designed and constructed assemblies featuring: (1) a high voltage, incoming section; (2) a power transformer; and (3) a low voltage distribution outgoing section. Provide transitional sections as recommended by the substation's manufacturer.[Substation shall be designed for outdoor service with ventilation openings and gasketing provided to ensure a weatherproof assembly under rain, snow, sleet, and hurricane conditions.] All enclosures shall conform to CEI EN 60529 for the actual environmental conditions encountered.[External doors shall have provisions for padlocking or other approved means of locking.]

2.5 SUBSTATIONS'S INCOMING SECTION[S]

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NOTE: This guide specification allows the unit substation with three options for the incoming section: (1) high voltage switch; (2) a high voltage switch assembly (multiple high voltage switches); and (3) high voltage circuit breaker. Consult with the Activity to determine their preferences and standards. Edit the specification

accordingly and type sentences as a single paragraph.
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CEI EN 60060-2, CEI EN 62271-102, CEI EN 60265-1, CEI EN 60298, CEI EN 60694, and CEI 17-1. High voltage[switch][switch assembly][circuit breaker] shall be approved and listed by a recognized European safety organization and shall have a "mark of quality" from such an organization. Comply with all requirements of the host nation.

[Provide additional auxiliary sections as required to accommodate metering and control features (including instrument and control transformers) indicated, specified, or otherwise required or recommended by the high voltage equipment manufacturer. Final arrangement shall be in accordance with the high voltage equipment manufacturer's recommendations and shall be approved by the Contracting Officer.]

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NOTE: Choose the first sentence option for a single, high voltage switch/circuit breaker. Choose the second group of sentences for a high voltage switch assembly.
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[The incoming section shall consist of a metal-enclosed, high voltage[switch][circuit breaker] for connecting the incoming circuit to the transformer.]

[The incoming sections shall consist of multiple metal-enclosed, high voltage switches (forming a high voltage switch assembly) for connecting the high voltage electrical distribution system to the transformer.[Switch configurations shall be as indicated on the drawings.][The switch assembly configuration shall consist of: (1) a non-fused switch serving "power input"; (2) a non-fused switch serving "power output"; and (3) a fused switch serving the power supply to the transformer.]]

If required for proper connection and alignment to the transformer, provide a transition section with the incoming section.[Provide one surge arrester for each phase of each incoming circuit. Arresters shall be in the circuit ahead of any disconnecting devices and shall be rated[[_____] kV][as indicated].] Provide a stainless steel or laser etched anodized aluminum nameplate for each high voltage section that contains a[switch][circuit breaker].

2.5.1 Conductor Termination

Provide cable terminations as specified in Section 16303, "Underground Electrical Work". High voltage conductor terminations shall be designed for terminating one single conductor cable per phase and shall be arranged for circuits entering from below.

2.5.2 High Voltage[Switch][Switch Assembly]

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NOTE: Specify one of the following styles of high

voltage switches; that is, conventional air switch versus a combination air switch with load interrupter. Consult with the Activity to determine their preferences and Station standards. A variety of high voltage switches are now available and each type has their advantages and disadvantages. This is also in comparison with a high voltage circuit breaker. Circuit breakers are more costly than fused switches, but may be needed where switching is frequent and quick reclosing is required.

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CEI EN 60060-2, CEI EN 62271-102, CEI EN 60265-1, and CEI 17-1. High voltage switches shall be approved and listed by a recognized European safety organization and shall have a "mark of quality" from such an organization. Fulfill all requirements of the host nation. Provide switches, accessories and features as indicated. Switches shall be insulated for [5][15][24][___] kV for use on [_____] kV system. Each steel unit forming part of the switch structure shall be self-contained and shall house the switch and all accessories and features. Provide a full height center and rear compartment for the[buses and] outgoing cable connections.[Switches shall be designed and constructed for individually mounted style, free-standing, floor mounted type, and totally self-contained.][Provide high voltage switch assembly consisting of multiple, free-standing, floor mounted type switches connected to a common bus bar system. The entire assembly shall be designed and constructed as an integrated assembly. Provide switch layout as indicated.] Provide a steel door for each switch compartment. Enclosures shall be designed for[indoor][outdoor] location and shall conform to CEI EN 60529 for the actual environmental conditions encountered.[Design the structure to allow for future additions.] Provide laminated plastic nameplates for each switch,[meter,] device, and cubicle to identify its function. Provide permanent labels for wiring and terminals corresponding to the designations on approved shop drawings. Mount nameplates on each compartment door.

[2.5.2.1 Conventional Air Switch

CEI EN 60265-1. Provide a three-pole, single-throw, deadfront, metal-enclosed, load-break switch with manual stored energy operator. Switch shall be[fused, with fuses mounted on a single frame][non-fused] and designed for easy inspection[and fuse replacement]. The switch shall be operated by a manually charged spring stored energy mechanism which shall simultaneously disconnect or connect ungrounded conductors. The moveable blade of the switch shall be deenergized when in the open position. The mechanism shall enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability. A ground bus shall extend the width of the switch enclosure and shall be bolted directly thereto. Connect frame of unit to ground bus. The door shall have an inspection window to allow full view of the position of the three switch blades through the closed door. Switch ratings shall be as follows:

a. [_____] kV, [_____] kV BIL for service on a [_____] kV system with a fault close rating of not less than [_____] amperes asymmetrical.

b. The switch shall be capable of carrying continuously or interrupting [_____] amperes with a momentary rating of [_____] amperes at [_____] kV.

c. Switch shall have provision for padlocking in the open and closed positions.

d.[Fuses shall be current limiting type rated [_____] amperes continuous, and [_____] amperes interrupting capacity.][Fuses shall be current limiting type rated approximately [_____] percent of the transformer full-load rating and in accordance with the fuse manufacturer's recommendation.]

][2.5.2.2 Combination Air Switch With Load Interrupter

Provide a three-pole, single-throw, deadfront, metal-enclosed, load-break switch with load interrupter and manual stored energy operator. The switch shall consist of automatic, visible blade disconnects in series with[vacuum][or][SF6] interrupters. Provide an interrupter for each phase. Switch shall be[fused, with fuses mounted on a single frame][non-fused] and designed for easy inspection[and fuse replacement]. The switch shall be operated by a manually charged spring stored energy mechanism which shall simultaneously disconnect or connect ungrounded conductors. The mechanism shall enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability. A ground bus shall extend the width of the switch enclosure and shall be bolted directly thereto. Connect frame of unit to ground bus. Switch ratings shall be as follows:

a. [_____] kV, [_____] kV BIL for service on a [_____] kV system with a fault close rating of not less than [_____] amperes asymmetrical.

b. The switch shall be capable of carrying continuously or interrupting [_____] amperes with a momentary rating of [_____] amperes at [_____] kV.

c. Switch shall have provision for padlocking in the open and closed positions.

d.[Fuses shall be current limiting type rated [_____] amperes continuous, and [_____] amperes interrupting capacity.][Fuses shall be current limiting type rated approximately [_____] percent of the transformer full-load rating and in accordance with the fuse manufacturer's recommendation.]

][2.5.2.3 High Voltage Switch Assembly

When indicated, provide multiple, high voltage switches interconnected by a common bus bar system to form a switch assembly.[Switch configurations shall be as indicated.][The switch assembly configuration shall consist of: (1) a non-fused switch serving "power input"; (2) a non-fused switch serving "power output"; and (3) a fused switch serving the power supply to a transformer.] Switches shall be as specified above. The switch assembly

shall include, but is not necessarily limited to, the following:

a. Phase buses and connections: Mount bus structure on insulated supports of high-impact, non-tracking, high-quality insulating material and brace bus to withstand the mechanical forces exerted during short-circuit conditions when connected directly to a source having maximum of [_____] amperes rms symmetrical available. Bus bars shall be rated [_____] amperes and shall be high conductivity copper. Make bus bar connections from main buses to the bus studs serving the respective switches. Equip outgoing switch studs with mechanical clamp type cable connectors for the size of cables shown. Provide cable supports for outgoing cables.

b. Ground bus: Provide a copper ground bus sized for full short-circuit capacity. Secure ground bus to each vertical structure and extend ground bus the entire length of the switch assembly. Include provisions for making the station ground connections.

]2.5.3 High Voltage Circuit Breaker

CEI 17-1. High voltage circuit breakers shall be approved and listed by a recognized European safety organization and shall have a "mark of quality" from such an organization. Fulfill all requirements of the host nation. Provide circuit breakers, accessories and features as indicated. Breakers shall be the[vacuum][or][SF6] type and shall be insulated for [5][15][24][__] kV for use on [_____] kV system. Each steel unit forming part of the circuit breaker structure shall be self-contained and shall house one breaker and a full height center and rear compartment for the outgoing cable connections. Equip circuit breaker compartments with drawout contacts, rails, disconnecting mechanism and a cell interlock to prevent moving the removable element into or out of the "connected" position while the circuit breaker is closed. Provide a steel door for each breaker compartment. Enclosures shall be designed for[indoor][outdoor] location and shall conform to CEI EN 60529 for the actual environmental conditions encountered.[Design the structure to allow for future additions.] Provide laminated plastic nameplates for each relay, switch, meter, device, and cubicle to identify its function. Provide permanent labels for wiring and terminals corresponding to the designations on approved shop drawings. Mount nameplates on each circuit breaker compartment door.

2.5.3.1 Specific Requirements

The circuit breaker shall be an electrically-operated, three-pole, circuit interrupting device rated for [_____] amperes continuous at [_____] kV and [_____] kV BIL. Breaker shall be designed for service on a [_____] kV system with a short-circuit capacity of not less than [_____][amperes symmetrical][MVA]. Circuit breaker shall be drawout-mounted with position indicator, operation counter, auxiliary switches, and primary and secondary disconnect devices. Circuit breaker shall be operated by an electrically charged, mechanically and electrically trip-free, stored-energy operating mechanism. Provide for manual charging of the mechanism. Circuit breaker control voltage shall be[[_____] VDC][[_____] VAC].[SF6 circuit breakers shall be shipped factory filled with SF6 gas.]

a. Contacts: Silver-plated, multifinger, positive pressure, self-aligning type for main drawout contacts.

b. Each drawout breaker shall be provided with three-position operation. The connected position and the test/disconnect position shall be clearly identified by an indicator on the circuit breaker front panel.

1. Connected position: Contacts are fully engaged. Breaker shall be tripped before it can be racked into or out of this position.

2. Test/disconnect position: Position shall allow for complete testing and operation of the breaker without energizing the primary circuit.

3. Withdrawn (removed) position: Places breaker completely out of compartment, ready for removal.

2.5.3.2 Breaker Lifter

Provide a portable lifter rated for lifting and lowering circuit breakers from cubicles. Portable lifter shall have swivel casters in front for ease of movement.[Provide a lifter for each substation.]

[2.5.4 Additional Requirements for High Voltage Circuit Breaker

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NOTE: Use this paragraph for circuit breakers at the Aviano Air Base in Aviano, Italy. It may be used (in whole or in part) at other project sites as approved by the respective Activity.
****

In addition to the requirements defined in the paragraph titled "High Voltage Circuit Breaker", provide the following requirements. Each circuit breaker assembly shall be an integrated assembly consisting of the following subassemblies: (1) circuit breaker; (2) bus bar line switch; (3) line disconnect switch; (4) ground disconnect switch; and (5) potential capacitor assembly. Provide operational features as specified below. Operational variations may be considered and shall only be allowed where specifically approved by the Contracting Officer. Provide auxiliary components such as[control and instrument transformers,][measuring instruments,][and] power relays as indicated on the drawings and as specified hereinafter. Panel (door) covers on the front of the primary switch assembly shall include microswitches that are electrically interlocked with the bus bar line switch. When any panel cover is opened, the microswitch shall cause the bus bar line switch to open.

2.5.4.1 Circuit Breaker

CEI 17-1. The circuit breaker shall be the SF6 circuit breaker type with a removable carriage assembly, mounted in its own cell and on suitable service skids. The service skids shall facilitate the breaker's extraction for inspection and maintenance operations. Each circuit breaker shall be

equipped with the following features:

a. Manual operation by means of pre-charged spring.

b. Mechanical indication of "charged", or "not charged" spring mechanism.

c. Auxiliary relay to indicate when circuit breaker is open.

d. Auxiliary contacts.

e. Mechanical interlock with the bus bar line switch.

f. Plug-in outlet for auxiliary features, operated by the circuit breaker carriage.

g. Electrical indication of the circuit breaker's open position (provide red pilot lamp) and closed position (provide green pilot lamp). Provide lamp assemblies with lamp test feature.

h. Electrical characteristics shall be as follows:

1. Rated voltage .....[24][___]kV

2. Rated current .....630 A

3. Rated frequency .....50 Hz

4. Withstand voltage at 50 Hz for 1 minute 50kV

5. Impulse withstand voltage .....125 kV

6. Short time current withstand 3 seconds .....16 kA

7. Symmetrical breaking capacity .....14.5 kA at 20 kV equal to 500 MVA

8. Rated making capacity .....40 kA

2.5.4.2 Voltage Transformers

Provide voltage transformers as defined in the paragraph entitled "Control and Instrument Transformers".

2.5.4.3 Bus Bar Line Switch

CEI EN 60265-1. Each circuit breaker assembly shall include a rotary type, bus bar line switch which shall isolate the circuit breaker from the switchgear's bus. The switch shall be mounted on resin epoxide insulators with high discharge surface of specialized construction to allow for installation in high moisture ambient and shall be resistant to partial power discharge. The switch shall provide separation between the bus bar and the circuit breaker with the circuit breaker either in its open position or close position. Provide switch with keyed interlock with the ground disconnect switch. Keyed operation shall allow the ground

disconnect switch to be closed only when the bus bar line switch has first been opened. The bus bar line switch shall also be interlocked with the line disconnect switch. Both switches shall open simultaneously. Electrical characteristics shall be as follows:

a. Rated voltage ..... [24][___] kV

b. Rated current .....630 A

c. Withstand voltage at 50 Hz for 1 minute .....50 kV

d. Impulse withstand voltage .....125 kV

e. Short time current withstand 1 second .....16 kA

f. Dynamic limit current (peak) .....40 kA

2.5.4.4 Line Disconnect Switch

CEI EN 60265-1. Each circuit breaker assembly shall include a rotary type, line disconnect switch which shall isolate the circuit breaker from the primary distribution system.[Switch construction shall be the same as required for the bus bar line switch.][The switch shall be mounted on resin epoxide insulators with high discharge surface of specialized construction to allow for installation in high moisture ambient and shall be resistant to partial power discharge. The switch shall provide separation between the bus bar and the circuit breaker with the circuit breaker either in its open position or close position.] Provide interlock with the bus bar line switch. Electrical characteristics shall be as follows:

a. Rated voltage .....[24][___] kV

b. Rated current .....630 A

c. Withstand voltage at 50 Hz for 1 minute .....50 kV

d. Impulse withstand voltage .....125 kV

e. Short time current withstand 1 second .....16 kA

f. Dynamic limit current (peak) .....40 kA

2.5.4.5 Ground Disconnect Switch

CEI EN 62271-102. Each circuit breaker assembly shall include a ground disconnect switch for the purposes of "grounding-out" the lower cell of the switch assembly. The ground disconnect switch shall be designed to withstand 16 kA for 1 second at a voltage value of [24][___] kV. Provide the following features:

a. Manual control on front of the primary switch assembly.

b. Mechanism on the front of the primary switch assembly to indicate if

the switch is open or if it's closed.

c. Removable control lever.

d. A keyed mechanical interlock with the bus bar line switch.

2.5.4.6 Potential Capacitor Assembly

Each circuit breaker assembly shall include a potential capacitor assembly. The potential capacitor assembly shall indicate if the lower cell of the switch assembly is electrically energized. The assembly shall include a small capacitor and disconnect switch with an indicator lamp. Whenever the lower cell is energized the lamp shall illuminate. Provide a lamp test switch. The assembly shall be rated for [24][___] kV.

]2.5.5 Protective Power Relays and Associated Devices

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NOTE: The definition and application of device function numbers used in electrical substations and switchgear are found in IEEE C37.2, "IEEE Standard Electrical Power System Device Function Numbers." The European power industry also uses these device function numbers. For description and application of commonly used relays, refer to MIL-HDBK-1004/3, "Switchgear and Relaying." This guide specification does not cover all possible relay applications. Choose only the relay types applicable to the specific project.

****

Protective power relays and associated devices shall be solid-state type[or induction type] enclosed in rectangular, semiflush, switchboard-type drawout cases with indicating targets and provisions for testing in place by use of manufacturer's standard test blocks or test switches. One complete set of test blocks or test switches to fit each type of relay in the equipment shall be provided. Auxiliary and lockout relays are not required to have drawout cases or test provisions. Controls, relays, and protective functions shall be provided completely assembled and wired.

a. Solid-state type relays with multiple functions may be submitted for consideration and approval by the Contracting Officer. Multiple functional relays may include additional features which are not specified. Protection and control functions that are provided and activated in addition to those functions that are specified shall be recommended by the equipment manufacturer and approved by the Contracting Officer.

b. Additional functions that are provided but not approved shall be capable of being totally deactivated. Unused protection features shall not affect the proper operation of the relay protection system as intended in this design. This shall especially apply to instantaneous operational features which are undesirable when time delay features and selectivity features are required.

2.5.5.1 Relay Requirements

Protective power relays and associated devices shall include, but not necessarily be limited to, the following:

a. Phase overcurrent relays (device [50/]51): Provide [_____] sets of three time overcurrent relays responding to phase currents wired to trip associated circuit breakers upon the occurrence of a current above the tap setting of the relays. Each relay shall have inverse time characteristics with a tap range of [_____] to [_____] amperes.[Each relay shall be equipped with an instantaneous overcurrent unit having a pickup value over the range of [_____] to [_____] amperes.][Relays shall be Type [_____].]

b. Ground overcurrent relays (device [50/]51N): Provide a time overcurrent relay responding to ground (residual) current, wired to trip the associated circuit breaker upon occurrence of ground current above the tap setting of the relay. Relay shall have[very][extremely] inverse time characteristics with a tap range of [_____] to [_____] amperes.[Relay shall be equipped with an instantaneous overcurrent unit having a pickup value adjustable over the range of [_____] to [_____] amperes.][Relays shall be Type [_____].]

c. Ground overcurrent relays (device 51N): Provide a time overcurrent relay responding to ground (residual) current, wired to trip the associated circuit breaker upon occurrence of ground current above the tap setting of the relay. Relay shall have[very][extremely] inverse time characteristics with a tap range of [_____] to [_____] amperes.[Relay shall be equipped with an instantaneous overcurrent unit having a pickup value adjustable over the range of [_____] to [_____] amperes.][Relays shall be Type [_____].]

[d. Fault pressure relay (device 63): Provide a fault pressure relay sensitive to rate of rise of transformer tank pressure to detect internal faults in transformer windings. Fault pressure relay shall be wired to a compatible auxiliary seal-in relay (Device 63X), which shall trip primary circuit breakers and transformer secondary breakers of the associated transformer via a lockout relay. Fault pressure relay shall be transformer mounted and auxiliary relay shall be panel mounted in a semiflush case. Auxiliary relay shall have trip-indicating targets.]

e. Directional phase overcurrent relays (device 67): Provide [_____] sets of three directionally controlled time overcurrent relays sensing phase current, wired to trip associated circuit breakers upon a current exceeding the tap setting in the direction indicated. Relays shall have a voltage polarized directional unit and an inverse time characteristic overcurrent unit. Overcurrent unit shall have a tap range of [_____] to [_____] amperes.[Relays shall be Type [_____].]

f. Lockout relays (device 86): Provide hand reset, electrically tripped, high-speed auxiliary relays where indicated. Relays shall be tripped by the indicated devices and shall be wired to trip the associated circuit breaker and prohibit closing of the circuit breaker by local

and remote controls until the lockout relay has been reset by hand to its normal position. Each relay shall be provided with the number of contacts required to perform the indicated function and, in addition, shall have a minimum of two spare normally closed contacts and two spare normally open contacts.

g. Thermal relay (device 49): Provide a winding thermal relay, with associated accessories including an electronic control unit. Equipment shall indicate the winding temperature of the transformer and shall serve the electronic control unit. The control unit shall provide automatic cooling fan control and shall serve the alarm system to provide a high temperature alarm feature and a high-high temperature shutdown feature.[Provide features necessary for remote indication of high temperature alarm and high-high temperature shutdown and connection to[an existing remote central monitoring system][a future Supervisory Control and Data Acquisition (SCADA) System].[The existing remote central monitoring system is made by [_____], [model number [_____]][style/type [_____]]. The new system shall be totally compatible with the existing system. The Contractor shall be totally responsible for coordinating and interfacing all interrelated equipment to the existing remote central monitoring system.]]

h. Auxiliary control relays: Provide as required to implement protective functions and interlocking as indicated. Auxiliary relays shall have contacts rated to carry 30 amperes for one minute and 12 amperes continuously. Coils shall be a long-life design with a projected service life of 40 years.

    1. Auxiliary relays used for tripping circuit breakers shall be multicontact, high-speed relays operating in one-half cycle or less.

    2. Auxiliary relays for functions other than tripping circuit breakers shall be normal-speed relays operating in two cycles or less.

    3. Auxiliary timing relays shall be[solid state][or][electro-pneumatic] relays with contacts rated for at least the load they are controlling.

2.5.6 Pilot and Indicating Lights for High Voltage Equipment

Provide pilot and indicating lights as indicated, as specified, and as otherwise required or recommended by the manufacturer of the respective electrical power equipment. Lights shall be transformer, resistor, or diode type. Color of lens covers shall be as indicated. Where the lens color is not specified, provide a color that is recommended by the equipment manufacturer. Each light shall have a legend plate which defines the function that is being indicated. (Examples: open, closed, tripped, and so forth.)

2.5.7 Primary Transition Section

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NOTE: Transition section should only be specified where absolutely necessary.

****

Provide transition section for cable or bus connections to the transformer primary terminals. Support connections between the high-voltage incoming section and the transformer primary by porcelain insulators, and size and brace the cable or bus to withstand the specified available fault.

2.6 POWER TRANSFORMERS

****

NOTE: Indicate and specify the type of transformer (or transformers) required for the project, that is, liquid insulated type versus dry type. Selection and design shall be based upon the following:

1. Consult with the Activity regarding preferences for transformer type (liquid insulated versus dry type). The designer must be aware of environmental requirements of the host nation. Oil insulated transformers may require spill containment systems that are expensive and require significant space and underground burial.

2. As a result of the environmental issues, the Aviano Air Base (Aviano, Italy) requires dry type transformers that must be mounted indoors.

3. If liquid insulated transformers are specified, then specify mineral oil insulation wherever possible. Less-flammable liquid insulated transformers may be used as approved by the Activity and when installed in accordance with the host nation's safety and environmental requirements. For interior liquid insulated transformers comply with all requirements defined in MIL-HDBK-1008, "Fire Protection for Facilities Engineering, Design, and Construction" and with the host nation's safety and environmental requirements.

4. If it is anticipated that future load requirements will necessitate increasing the capacity of the transformer, the specification for the transformer should require the provision of components and brackets for future forced air cooling and mechanical circulation for the coolant fluid (if liquid insulated).

5. If forced-air-cooling is immediately specified, define such requirements on the drawings, provide associated details, and define the operational control features.

****

CEI 14-8, CEI EN 60076-1, CEI EN 60076-2, CEI EN 60076-10. Power transformers shall be approved and listed by a recognized European safety organization and shall have a "mark of quality" from such an organization. Comply with requirements of the host nation. Transformers shall be[forced-air-cooled,][oil insulated][less-flammable liquid insulated][dry type] rated [_____] kVA, 50 Hz, three-phase, [_____] kV, [_____] kV BIL, primary connected[delta][wye] to [_____] V secondary connected[delta][wye]. High voltage bushings and low voltage bushings shall be coordinated to provide the optimum connections to the respective high voltage and low voltage power equipment and the associated equipment to which the transformer is connected. Bushings shall be accessible for connection, inspection and maintenance purposes.[Forced-air-cooling fans shall have[automatic temperature control unit][winding temperature indicator with sequence contacts].] Minimum tested impedance shall be not less than [_____] percent. Transformers shall have [four][_____] externally operated 2 1/2 percent full capacity taps, [two][_____] above and [two][_____] below rated voltage. Provide low voltage neutral bushings on units having wye connected low voltage windings. Transformer shall have stainless steel or laser etched anodized aluminum diagrammatic nameplate. Transformer's sound levels shall be in accordance with CEI EN 60076-10.[All transformers shall be designed and approved for parallel operation. Provide matching and electrically identical transformers that are parallel connected.][Transformer shall have fully equipped provisions for the future and simple addition of automatically controlled cooling fans.]

****

NOTE: 55/65 degrees C rise provides an additional 12 percent kVA capacity when the unit is operated at 65 degrees C. This is a safe means of overloading the base kVA rating of a transformer without affecting its life. Additional cost for 55/65 rise is minimal when compared to the purchase of the next larger standard kVA size unit.

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2.6.1 [Liquid Insulated][Less-Flammable Liquid Insulated]Transformers

CEI 14-13. [Liquid insulated][Less-flammable liquid insulated] transformers shall have an insulation system rated[55/65][65] degrees C rise to allow transformers to have a continuous overload capacity of 12 percent at rated voltage without exceeding 65 degrees C winding temperature rise above 40 degrees C maximum ambient. Provide identification of transformer as "non-PCB" on the nameplate. The insulated liquid shall be[a mineral oil][a less-flammable insulated liquid].[The less-flammable insulated liquid shall have a fire point not less than 300 degrees C and a dielectric strength not less than 33 kV. Do not provide nonflammable transformer liquids including askarel and insulating liquids containing polychlorinated biphenyls (PCB's), tetrachloroethylene (perchloroethylene), chlorine compounds, and halogenated compounds.] Each transformer shall include the following devices.

a. Pressure-vacuum gauge.

b. Bucholtz relay and associated control circuitry.

c. Pressure relief device.

d. Thermometer,[dial type][digital electronic type].

e. Liquid-level gauge, dial type.

f. Drain valve with sampling device.

g. Upper filter plug.

h. Ground connection provisions.

i. Lifting lugs (4 minimum).

[j. Electronic type temperature alarm and control unit with: (1) high temperature alarm feature; (2) high-high temperature shutdown feature; (3) all control devices for operating automatically controlled cooling fans, and (4) all associated control circuitry. Provide a separate temperature sensor or combine operations with the transformer's thermometer.]

2.6.2 Dry Type Transformers

CEI 14-8. Dry type transformers shall be the cast resin type, thermal class F, Dyn 11 vector group, and provided with a ventilated metal enclosure. Enclosure shall be rated [IP 31][___] (except the bottom may be rated [IP 21][___]) in accordance with CEI EN 60529. The transformer's core shall be composed of magnetic sheets, grain oriented, cold laminated and provided with mineral oxide insulating material. All magnetic sheets shall be treated with corrosion protection. High voltage and low voltage windings shall be aluminum with cast epoxy resin applied by a vacuum process. Each transformer shall include the following devices:

a. Winding thermal sensors with termination box and digital temperature display unit.

b. Ground connection provisions.

c. Lifting lugs.

d. Sliding rollers with mounting channels and provisions for seismic anchoring.

e. Hooks for towing in all directions.

[f. Electronic type temperature alarm and control unit with: (1) high temperature alarm feature; (2) high-high temperature shutdown feature; (3) all control devices for operating automatically controlled cooling fans; and (4) all associated control circuitry. Provide separate temperature sensors or combine operation with the digital temperature display unit.]

2.6.3 Secondary Transition Section

The secondary transition section shall have a hinged front panel, a [_____] ampere, three-phase,[three][four]-wire[insulated] main bus and connections, a ground bus, necessary terminal blocks, wiring and control buses,[control power transformer,] and all associated supports.

2.7 SUBSTATION'S OUTGOING SECTIONS: LOW VOLTAGE SWITCHGEAR AND CONTROLGEAR

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NOTE: A variety of features are available for low voltage switchgear. These features are dependent upon the ampacity rating of the switchgear. Switchgear up to 3200 amps is available that can be mounted against a wall and all terminations are accessible from the front. Larger ampacity switchgear requires rear access for power conductors terminations. The designer must determine equipment availability for the ampacities selected and must provide a design layout that provides proper and safe access around the switchgear. If power air circuit breakers are selected, then they shall be drawout type and rear access shall be provided. Lastly, it is customary European practice (Contractor's preference) to mount motor controllers with their respective circuit breakers. Subsequently, motor control features are included in this specification and must be edited accordingly. Include EN 60947-7-1 if the switchgear includes either motor control features or electrical metering.

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CEI EN 60439-1, CEI EN 60439-2, CEI EN 60529, CEI EN 60947-1,[and] CEI EN 60947-2[, CEI EN 60947-4-1,[and] CEI EN 60947-5-1][, and CEI EN 60947-7-1]. Low voltage switchgear shall be approved and listed by a recognized European safety organization and shall have a "mark of quality" from such an organization. Low voltage switchgear shall be deadfront, metal-enclosed, self-supported type and factory assembled. Main bus shall be rated [_____] amperes at [380Y/220][_____] volts, three phase, five wires (3PH & N & G), for a [TN-S][_____] type distribution system, and shall have a short-circuit-current rating of [_____] rms symmetrical amperes. Voltage and amperage ratings shall be based upon a 40 degree C environment. Bus bars shall have an "insulation degree 4" rating. Devices shall be front accessible. Align sections of low voltage switchgear in front and rear. Provide low voltage switchgear in an enclosure that is approved for the environment that is actually encountered and in accordance with CEI EN 60529. Low voltage switchgear shall be completely factory engineered and assembled, including protective devices and equipment indicated with necessary interconnections[, instrumentation, and control wiring].[Provide provisions for future extension of the switchgear.] Circuit breakers that serve auxiliary equipment shall be in accordance with CEI EN 60934. Fuses that serve auxiliary equipment shall be in accordance with CEI EN 60269-1.

2.7.1 Low Voltage Switchgear's General Selection

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NOTE: Low voltage switchgear can be specified with the manufacturer's standard partitioning configuration or with partitioning forms in accordance with EN 60439-1. Form 2 provides upstream and downstream partitioning of the incoming device, partitioning of the busbars, and upstream terminal shields on installed devices. Form 3 includes all the partitioning features of Form 2 plus it also provides horizontal barriers. Form 4 includes all the features of Form 3 plus downstream terminal shields on motor control circuit breakers and personnel protection against contact with functional units. The higher the form number, the more expensive the switchgear. If power air circuit breakers are specified for the distribution section, then Form 4 partitioning must also be specified.

****

Low voltage switchgear type required for this project is a main service style low voltage switchgear. Switchgear shall be provided as indicated on the drawings and as specified in this specification.

2.7.1.1 Main Service Style Low Voltage Switchgear

Switchgear shall include[front and rear access][front access only]. Conductor termination access shall be provided from the[front][rear] of the switchgear.[The switchgear shall be designed and constructed for mounting against a wall.][Manufacturer's standard partitioning shall be provided.][Provide form[2] [3][4] partitioning in accordance with CEI EN 60439-1.]

2.7.2 Bus Bars

CEI EN 60439-2. Bus bars shall be[copper][or][aluminum]. Make bus connections and joints with hardened steel bolts.[Provide pressure (Belleville) washers on aluminum bus connections and joints.] A full-capacity bus shall connect sections together[and shall have provisions for future extension]. Buses shall be completely insulated from the devices so that the only exposed energized parts will be at the point of connection to devices. Support and brace the buses for the short-circuit current specified. Provide and secure ground bus to each vertical section and extend ground bus the entire length of the structure. Size neutral bus for [100][_____] percent of full load amperes.

2.7.3 Main Protective Device

Provide individually mounted[drawout][stationary] main circuit breaker removable from the front of the switchgear. The circuit breaker shall be the[low voltage power air circuit breaker][compact (molded case) circuit breaker] type. Service, maintenance and replacement of the circuit breaker

shall be accomplished from the front of the switchgear.

****

NOTE: Choose one of the following options. Be sure to define all electrical ratings (amps, volts, AIC/MIC) on the drawings. Provide ground fault protection of equipment for solidly grounded wye electrical services of more than 150 volts to ground for each service disconnect rated 1000 amperes and higher.

****

[2.7.3.1 Compact (Molded Case) Circuit Breakers

CEI EN 60947-2. Provide[manually][electrically] operated, 100 percent rated, and with electrical ratings as indicated on the drawings. Series rated and cascade rated circuit breakers are unacceptable. Breaker frame size, sensor rating, and overcurrent protective device (rating plug) shall be as indicated. Breaker shall be equipped with solid-state trips, with current sensors and solid-state logic circuits integral to the circuit breaker. The solid-state trip device shall provide adjustable ampere settings with adjustable long time delay[,][and] adjustable short time delay[and adjustable ground fault] characteristics so that branch breakers will normally trip first on overload and at lower fault current levels. Settings shall be located behind cover to deter tampering.

][2.7.3.2 Low Voltage Power Air Circuit Breaker

CEI EN 60947-2. Provide[electrically][manually] operated, 100 percent rated, stored energy drawout low-voltage power air circuit breaker with electrical ratings as indicated on the drawings. Breaker frame size, sensor rating, and overcurrent protective device (rating plug) shall be as indicated. Equip breaker with solid-state trip device with adjustable long time[,][and] adjustable short time[and adjustable ground fault] tripping characteristics so that branch breakers will normally trip first on overload and at lower fault current levels.[Equip electrically operated breakers with motor-charged, stored-energy closing mechanism to permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle.]

a. Contacts: Silver-plated, multifinger, positive pressure, self-aligning type for auxiliary, control, and main drawout contacts.

b. Each drawout breaker shall be provided with four-position operation. Each position shall be clearly identified by an indicator on the circuit breaker front panel.

    1. Connected Position: Primary and secondary contacts are fully engaged. Breaker must be tripped before racking into or out of position.

    2. Test Position: Primary contacts are disconnected but secondary contacts remain fully engaged. Position shall allow complete test

and operation of the breaker without energizing the primary circuit.

3. Disconnected Position: Primary and secondary contacts are disconnected.

4. Withdrawn (Removed) Position: Places breaker completely out of compartment, ready for removal. Removal of the breaker shall actuate assembly which isolates the primary stabs.

]2.7.4 Distribution Section

****

NOTE: Coordinate drawing details and elevations with specification. Define on the drawings which feeder breakers (if any) are to have solid-state trip devices.

Secondary feeder breaker trips will not necessarily be uniformly set. Coordinate trip settings with the upstream main breaker and with all downstream load breakers.

The distribution circuit breakers can be either group mounted or individually mounted. Availability of mounting styles may be limited relative to the circuit breaker's frame size. Larger frame sizes are only available as individually mounted circuit breakers. Individually mounted circuit breakers may require rear access to the switchgear. Therefore, the substation cannot be mounted against a wall. If the switchgear includes motor starters, then individually mounted equipment is preferred. The designer is responsible for the layout, access and clearances of the entire unit substation. Be sure these physical elements are fully defined and coordinated between the drawings and the specifications.

Specify compact (molded case) circuit breakers unless power air circuit breakers are specifically desired and approved by the Station/Base.

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[CEI EN 60947-2. Provide[group][individually] mounted, stationary style, compact (molded case) circuit breakers arranged to allow removal and interchanging from the front of the low voltage switchgear without disturbing adjacent breakers or associated devices. Provide electrical ratings (amps, volts, AIC/MIC) as indicated on the drawings. Series rated and cascade rated circuit breakers are unacceptable. Where indicated, "space" shall mean to include bus, device supports, connections and all components required to provide for the direct and simple installation of a future circuit breaker. Spaces shall be fully equipped so that only the circuit breaker needs to be obtained in order to "activate" the space.[

Each individually mounted breaker and associated devices shall be isolated in its own compartment and shall be positioned vertically with operating handles extending through a hinged front cover. Each breaker shall be individually bus connected to the main bus of the low voltage switchgear.] The load side of each breaker[(or associated power device such as a[motor starter][or][contactor])] shall be bus connected to cable lugs. Provide additional component and accessories (such as[motor starters,][contactors,][control switches,] pilot lights, terminal boards, and so forth) as indicated on the drawings.]

[CEI EN 60947-2. Provide individually mounted,[electrically][manually] operated, 100 percent rated, stored energy drawout low voltage power air circuit breakers with electrical ratings as indicated on the drawings. Breaker frame size, sensor rating, and overcurrent protective device (rating plug) shall be as indicated. Equip breakers with solid-state trip device with adjustable long time[,][and] adjustable short time[and adjustable ground fault] tripping characteristics so that branch breakers will normally trip first on overload and at lower fault current levels. Settings shall be located behind cover.[Equip electrically operated breakers with motor-charged, stored-energy closing mechanism to permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle.] The load side of each breaker[(or associated power device such as a[motor starter][or][contactor])] shall be bus connected to cable lugs located at the rear of the low voltage switchgear. Provide additional component and accessories (such as[motor starters,][contactors,][control switches,] pilot lights, terminal boards, and so forth) as indicated on the drawings.

a. Contacts: Silver-plated, multifinger, positive pressure, self-aligning type for auxiliary, control, and main drawout contacts.

b. Each drawout breaker shall be provided with four-position operation. Each position shall be clearly identified by an indicator on the circuit breaker front panel.

    1. Connected Position: Primary and secondary contacts are fully engaged. Breaker must be tripped before racking into or out of position.

    2. Test Position: Primary contacts are disconnected but secondary contacts remain fully engaged. Position shall allow complete test and operation of the breaker without energizing the primary circuit.

    3. Disconnected Position: Primary and secondary contacts are disconnected.

    4. Withdrawn (Removed) Position: Places breaker completely out of compartment, ready for removal. Removal of the breaker shall actuate assembly which isolates the primary stabs.

][2.7.4.1 Solid-State Trip Devices

[Where specifically indicated, circuit breakers][Circuit breakers]shall be equipped with solid-sate trips, with current sensors and solid-state logic circuits integral to the circuit breaker. The solid-state trip device shall provide adjustable ampere settings with adjustable long time delay, and adjustable short time delay characteristics so that branch breakers will normally trip first on overload and at lower fault current levels. Settings shall be located behind cover to deter tampering.[Where specifically indicated, provide ground fault protection having solid-state circuitry as an integral part of the solid-state trip device.]

][2.7.4.2 Circuit Breaker Handles

Handles for individually mounted devices shall be of the same design and method of external operation. Label handles prominently to indicate device ampere rating, color coded for device type. Identify ON-OFF indication by handle position and by prominent marking.

]2.7.5 Motor Control Features

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NOTE: Motor and motor controller specifications shall be thoroughly coordinated with and cross-referenced in all affected sections which specify motor operated and motorized equipment. Delete all "motor control feature" paragraphs if the switchgear does not include any motor starters. Otherwise, edit the respective paragraphs based upon the actual project design and conditions.

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CEI EN 60947-4-1, CEI EN 60947-5-1, and CEI EN 60947-7-1. The phrases "motor controller" and "motor starter" shall mean the same thing and shall be interchangeable. Motor control features shall include, but not necessary be limited to, the following requirements:

a. Circuit breakers shall be specifically rated for motor service and the final breaker selection shall be coordinated with the actual motor provided. Similarly, motor starters shall have utilization category that is coordinated with the actual motor provided.

b. Electrical ratings of circuit breakers and motor starters shall be as indicated on the drawings unless the size of the motor and equipment served has been revised from the size indicated. Final electrical ratings shall be coordinated with and based upon the actual size and type of the motor and equipment served.

c. Motor starters shall have thermal overload protection in each phase and shall have one spare normally open and one spare normally closed auxiliary contact. Overload protective devices shall provide adequate protection to the motor windings; shall be the thermal inverse-time-limit type; and shall include a manual reset type pushbutton on the outside of the low voltage switchgear door cover.

d. Magnetic type motor starters shall have undervoltage protection when

used with momentary contact pushbutton switches and shall have undervoltage release when used with maintained contact pushbutton switches.

e. When used with pressure, float, or similar automatic type of maintained contact switch, motor starter shall have hand/off/automatic selector switch. Connections to the selector switch shall be such that only normal automatic regulatory control devices are bypassed when the switch is in its "hand" position. Safety control devices (such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices) shall be connected in the motor control circuit's "hand" and "automatic" positions.

f. Control circuit connections shall be made in accordance with an approved wiring diagram. Fulfill instructions and recommendations of all associated manufacturers.

g. For each motor not in sight of its motor starter, the starter's disconnecting means shall be capable of being locked in its open position. As an alternative, provide a manually operated, lockable, nonfused switch within sight of the motor and which disconnects the motor from its supply source.

h. Provide enclosures rated for the actual environment encountered and in accordance with CEI EN 60529.

2.7.5.1 Control Circuits

CEI EN 60947-5-1. Control circuits shall have maximum voltage of 220 volts. Coordinate control circuits with the actual motors and equipment provided. Fulfill all instructions and recommendations of the associated equipment manufacturers.

2.7.5.2 Multiple-Speed Motor Controllers and Reversible Motor Controllers

Provide across-the-line-type, electrically and mechanically interlocked type. Multiple-speed controllers shall have compelling relays and shall be multiple-button, station-type with pilot lights for each speed.

2.7.5.3 Pushbutton Switches

Provide pushbutton switches with "start/stop" momentary contacts having one normally open and one normally closed set of contacts, and a red pilot light to indicate when motor is running. Switches shall be heavy duty, oil-tight type.

2.7.5.4 Pilot Lights

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NOTE: Requirements for pilot lights must be defined either on the drawings or in the specification section which specifies the motor operated or electrified equipment. The color of lens covers must also be defined and coordinated.

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Provide transformer, resistor, or diode type pilot lights. Color of lens covers shall be as indicated. Where the lens color is not specified, provide a color that is recommended by the equipment manufacturer. Each pilot light shall have a legend plate (30 mm by 40 mm minimum size) which defines the function that is being indicated. (Examples: on, off, run, emergency stop, and so forth.)

2.7.5.5 Terminal Blocks

CEI EN 60947-7-1. All field wiring that serves a control circuit shall be terminated in a dedicated terminal block (or blocks) that is mounted in the low voltage switchgear cubicle that serves the associated motorized equipment.

2.7.5.6 Reduced-Voltage Motor Starters

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NOTE: The designer must determine, based on the power system characteristics and motor usage, where reduced-voltage starters must be specified. See MIL-HDBK-1004/4, "Electrical Utilization Systems," for detailed discussion of these reduced voltage starter types and for guidance in their selection and application.

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Reduced-voltage motor starters shall be single-step, closed transition[autotransformer type,][or][reactor type,][or][primary resistor type,][or][solid state type,] and shall have adjustable time interval between application of reduced and full voltages to the motor. The final motor starter selected shall be approved by the manufacturer of the equipment served.

2.7.6 Electrical Metering for Low Voltage Switchgear

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NOTE: Coordinate with the Activity to determine Station requirements, preferences and any special requirements for connecting to existing basewide monitoring systems, if any. Not all low voltage switchgear warrant metering. Be sure to show metering on the drawings both on the electrical power diagrams and on the elevation view of the low voltage switchgear. Also, current transformer sizes and quantities must be defined on the drawings. Do not specify waveform capture features and communication features unless specifically instructed. Drawings must also define where meters with circuit monitoring functions are specifically required.

****

Provide switchboard style, electronic, digital multimeters with quantity and locations as indicated on the drawings. Meters shall be the semi-drawout, semi-flush mounted type and mounted on the panel cover of the low voltage switchgear. Meters shall be coordinated with the electrical system requirements and shall conform to CEI EN 61010-1. Meters shall measure true RMS values through the 31st harmonic value, shall have a minimum accuracy of [1.0][___] percent. Meter display readings shall be direct values and shall not require any multiplier factors. Voltage input shall be direct and shall not require voltage transformers. Provide fuse protection for each phase conductor of the voltage supply circuit. Fuses shall comply with CEI EN 60269-1 and shall be selected and sized as recommended by the meter manufacturer. Provide a current transformer conforming to CEI EN 60044-1 for each phase of the electrical system and coordinate the meter with ratios of the transformers. The meter shall include local display with a two line by 16 character LCD screen for the readout of all metered and diagnostic values. Values shall be defined to six digits. Meter shall include local operational features for "selection and mode" functions and scrolling features to observe the metered values. Setup and reset features shall be password protected and easily accomplished through the meter's display system.

2.7.6.1 Measured Values

Measured values shall include, but not necessarily be limited to, the following:

a. Current each phase and in the neutral (A).

b. Line-to-line voltages (V).

c. Line-to-neutral voltages (V).

d. Real power (kW).

e. Reactive power (kVAR.)

f. Apparent power (kVA).

g. True power factor (PF).

h. Frequency (Hz).

i. Real energy (kWh).

j. Reactive energy (kVARh).

k. Apparent energy (kVAh)

l. KYZ output (pulse initiation feature for remote energy monitoring) with connection features to central monitoring station.

m. Total harmonic distortion (THD) for current and voltage.

n. Demand current (A).

o. Real power demand (kWd).

p. Reactive power demand (kVARd).

q. Apparent power demand (kVAd).

r. Date/time stamping.

[2.7.6.2 Digital Multimeters With Circuit Monitor Functions

Digital multimeters with circuit monitor functions shall be the same as defined for digit multimeters except that they shall also have programmable circuit monitoring functions as defined below. Quantity and locations of these enhanced meters shall have a communication port located on the front of the meter. The port shall serve a handheld programming unit which shall be used to program the meter, reset values, download data stored in memory, and similar functions. Provide [one][____] handheld programming unit[s] and turn over to the Contracting Officer.[The meter shall also be capable of being programmed and downloaded by an existing remotely located, central monitoring station. Provide all programming software necessary to download, analyze, evaluate and document the data retrieved and stored by the meter. The program shall include customized report documentation and printout features. Provide an instruction manual for loading and operating the associated programs. Programs shall be designed for use on a personal computer with [Microsoft] [_____] operating systems.] The additional measured values and diagnostic features shall include, but not necessarily limited to, the following:

a. Onboard alarms (under/over conditions and phase unbalance conditions).

b. Minimum/maximum readings for current, voltage, power, power factor, frequency and THD values.

c. Data and event logging.

[d. Waveform capture.]

[e. Communication features for reporting all measured parameters and diagnostic features to an existing remote central monitoring system. The existing system is manufactured by [_____], model number [_____], and includes a [_____] communication protocol system. The metering equipment provided and its associated communication system shall be totally compatible with the existing system. The Contractor shall be totally responsible for coordinating and interfacing all interrelated equipment with the existing system.]

][2.7.7 Watthour Meters for Low Voltage Switchgear

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NOTE: Use this paragraph only if digital multimeters are not specified and the Activity desires power monitoring.

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CEI EN 61010-1. Provide a switchboard style electronic programmable watthour meter, semi-drawout, semi-flush mounted, as indicated. Meter shall either be programmed at the factory or shall be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of the project. Meter shall be coordinated with the electrical system requirements and shall conform to CEI EN 61010-1.

****

NOTE: When Section 15910, "Direct Digital Control Systems" is used, coordinate meter requirements.

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a. Design: Provide meter designed for use on the voltage system specified. Provide 3 current transformers. Provide meter with KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS)[as specified in Section 15910, "Direct Digital Control Systems"].

b. Coordination: Provide meter coordinated with ratios of current transformers and transformer secondary voltage. Meter shall be designed for direct voltage input and shall not require voltage transformers.

c. Accuracy: +/- 1.0 percent.

d. Kilowatt-hour Register: 5 digit electronic programmable type.

e. Demand Register:

1. Provide solid state type.

2. Provide a direct reading meter. A multiplier factor shall not be required.

3. Provide demand interval length programmed for[15][30][60] minutes with rolling demand up to six subintervals per interval.

f. Meter fusing: CEI EN 60269-1. Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to the watthour meter. Size fuses as recommended by the meter manufacturer.

]2.7.8 Low Voltage Current Transformers

CEI EN 60044-1. Transformers shall be bus bar mounted, single ratio, 50 hertz, 5 amp output rating, and a metering accuracy class of 0.5. Ratios shall be as indicated on the drawings. Low voltage current transformers shall have an insulation rating of 1 kV.

2.8 ELECTRICAL METERING FOR HIGH VOLTAGE SYSTEM

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NOTE: Do not specify metering for the high voltage system unless specifically required by the Activity. Additional high voltage cubicle will be required to serve the voltage (potential) transformers. Space for the metering equipment will also be required. All additional physical requirements for high voltage metering must be defined on the drawings and in the specifications.

****

2.8.1 Control and Instrument Transformers

2.8.1.1 Current Transformers

CEI EN 60044-1. Transformers shall be single ratio as indicated, 50 Hz, and coordinated to the rating of the associated switchgear, relays, meters, and instruments. Transformers shall be manufactured with fire resistant epoxide resin resistant to partial power discharge. Electrical characteristics shall be as follows:

a. Rated voltage .....[24][___] kV

b. Step down ratio .....As indicated

c. Withstand voltage at 50 Hz for 1 minute .....50 kV

d. Impulse withstand voltage .....125 kV

e. Thermal current for 1 minute .....16 kA

f. Dynamic and rated current .....2.2 I term

g. Precision class of measurement 0.5%

h. Precision class of protection .....5.P.

i. Safety factor of performance 10

j. Minimum performances .....Adequate

2.8.1.2 Voltage (Potential) Transformers

CEI EN 60044-2, CEI EN 60269-1 and CEI EN 60934. Transformers shall be[stationary][drawout] type, 50 Hz, with voltage ratings and ratios coordinated to the ratings of the associated switchgear, relays, meters, and instruments. Transformers shall have a fuse in each phase conductor of the transformer's primary circuit. Each phase conductor of the secondary shall also have fuse or circuit breaker protection. Fuses shall be current limiting and sized as recommended by the voltage transformer manufacturer. Transformers shall be manufactured with fire resistant epoxide resin resistant to partial power discharge. Electrical characteristics shall be as follows:

a. Rated voltage .....[24][___] kV

b. Transformer ratio .....As indicated

c. Withstand voltage at 50 Hz for 1 minute .....50 kV

d. Impulse withstand voltage .....125 kV

e. Precision class for measurement 0.5%

f. Minimum performance .....Adequate

[2.8.2 Electrical Metering Unit for High Voltage System

****

NOTE: Coordinate with the Activity to determine Station requirements, preferences and any special requirements for connecting to existing basewide monitoring systems, if any. Not all high voltage switchgear warrant metering. Be sure to show metering on the drawings both on the electrical power diagrams and on the elevation view of the high voltage section. Also, current transformers and voltage (potential) transformers (sizes and quantities) must be defined on the drawings. Do not specify waveform capture features and communication features unless specifically instructed. Drawings must also define where meters with circuit monitoring functions are specifically required.

****

[Electrical metering for the high voltage system shall be the same as required for "Electrical Metering for Low Voltage Switchgear" except that metering shall be coordinated for the high voltage current and voltage supply circuits and their respective current transformers and voltage transformers.]

[Provide switchboard style, electronic, digital multimeters with quantity and locations as indicated on the drawings. Meters shall be the semi-drawout, semi-flush mounted type and mounted on the panel cover of the high voltage switchgear. Meters shall be coordinated with the electrical system requirements and shall conform to CEI EN 61010-1. Meters shall measure true RMS values through the 31st harmonic value, shall have a minimum accuracy of [1.0][___] percent. Meter display readings shall be direct values and shall not require any multiplier factors. Provide fuse protection for each phase conductor of the voltage supply circuit. Fuses shall comply with CEI EN 60269-1 and shall be selected and sized as recommended by the meter manufacturer. Provide a current transformer for each phase of the electrical system and coordinate the meter with ratios of the transformers. The meter shall also be properly coordinated with the voltage transformers and the circuit properly protected. The meter shall include local display with a two line by 16 character LCD screen for the readout of all metered and diagnostic values. Values shall be defined to six digits. Meter shall include local operational features for "selection

and mode" functions and scrolling features to observe the metered values. Setup and reset features shall be password protected and easily accomplished through the meter's display system.]

2.8.2.1 Measured Values

Measured values shall include, but not necessarily limited to, the following:

a. Current each phase and in the neutral (A).

b. Line-to-line voltages (V).

c. Line-to-neutral voltages (V).

d. Real power (kW).

e. Reactive power (kVAR.)

f. Apparent power (kVA).

g. True power factor (PF).

h. Frequency (Hz).

i. Real energy (kWh).

j. Reactive energy (kVARh).

k. Apparent energy (kVAh)

l. KYZ output (pulse initiation feature for remote energy monitoring) with connection features to central monitoring station.

m. Total harmonic distortion (THD) for current and voltage.

n. Demand current (A).

o. Real power demand (kWd).

p. Reactive power demand (kVARd).

q. Apparent power demand (kVAd).

r. Date/time stamping.

[2.8.2.2 Digital Multimeters With Circuit Monitor Functions

Digital multimeters with circuit monitor functions shall be the same as defined for digit multimeters except that they shall also have programmable circuit monitoring functions as defined below. Quantity and locations of these enhanced meters shall have a communication port located on the front of the meter. The port shall serve a handheld programming unit which shall be used to program the meter, reset values, download data stored in memory, and

similar functions. Provide [one][___] handheld programming unit[s] and turn over to the Contracting Officer.[The meter shall also be capable of being programmed and downloaded by an existing, central monitoring station (that is, remote monitoring). Provide all programming software necessary to download, analyze, evaluate and document the data retrieved and stored by the meter. The program shall include customized report documentation and printout features. Provide an instruction manual for loading and operating the associated programs. Programs shall be designed for use on a personal computer with [Microsoft] [_____] operating systems.] The additional measured values and diagnostic features shall include, but not necessarily limited to, the following:

a. Onboard alarms (under/over conditions and phase unbalance conditions).

b. Minimum/maximum readings for current, voltage, power, power factor, frequency and THD values.

c. Data and event logging.

[d. Waveform capture.]

[e. Communication features for reporting all measured parameters and diagnostic features to the existing central monitoring system. The existing system is manufactured by [_____], model number [_____], and includes a [_____] communication protocol system. The metering equipment provided and its associated communication system shall be totally compatible with the existing system. The Contractor shall be totally responsible for coordinating and interfacing all interrelated equipment with the existing system.]

]][2.8.3 Watthour Meters for High Voltage System

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NOTE: Use this paragraph only if digital multimeters are not specified and the Activity desires power monitoring on the high voltage system.
****

[Watthour metering for the high voltage system shall be the same as required for "Watthour Meters for Low Voltage Switchgear" except that metering shall be coordinated for the high voltage current and voltage supply circuits and their respective current transformers and voltage transformers.]

[CEI EN 61010-1. Provide a switchboard style electronic programmable watthour meter, semi-drawout, semi-flush mounted, as indicated. Meter shall either be programmed at the factory or shall be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of the project. Meter shall be coordinated with the electrical system requirements and shall conform to CEI EN 61010-1.

a. Design: Provide meter designed for use on the voltage system specified. Provide 3 current transformers. The meter shall also be

properly coordinated with the voltage transformers and the circuit properly protected. Provide meter with KYZ pulse initiation hardware.[Meter shall be fully equipped for the direct and simple connection to a future central monitoring system.][Connect meter to the Station's existing central monitoring system. The existing system is manufactured by [_____], model number [_____], and includes a [_____] communication protocol system. The metering equipment provided and its associated communication system shall be totally compatible with the existing system. The Contractor shall be totally responsible for coordinating and interfacing all interrelated equipment with the existing system.]

b. Coordination: Provide meter coordinated with ratios of current transformers and voltage (potential) transformers.

c. Accuracy: +/- 1.0 percent.

d. Kilowatt-hour Register: 5 digit electronic programmable type.

e. Demand Register:

1. Provide solid state type.

2. Provide a direct reading meter. A multiplier factor shall not be required.

3. Provide demand interval length programmed for[15][30][60] minutes with rolling demand up to six subintervals per interval.

f. Low Voltage Meter Fusing: CEI EN 60269-1. Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to the watthour meter. Size fuses as recommended by the meter manufacturer.

]]2.9 HEATERS

Provide 220 volt heaters in each[high voltage equipment section][and in each][low voltage switchgear section]. Heaters shall be of sufficient capacity to control moisture condensation in the compartments, shall be 250 watts minimum, and shall be controlled by a thermostat[and humidistat] located in each section. Thermostat shall be industrial type, high limit, to maintain compartments within the range of 15.5 to 32.2 degrees C.[Humidistat shall have a range of 30 to 60 percent relative humidity.] Supply the heaters from a circuit breaker located in the low voltage switchgear section. Provide a pilot light and nameplate on the front of the low voltage switchgear section. Pilot light shall define electrical power is "on" to serve the heaters.[Energize electric heaters while the equipment is in storage or in place prior to being placed in service. Provide method for easy connection of heater to external power source.]

[2.10 DC POWER SYSTEM

CEI UNI EN 45510-2-3 and CEI EN 60896-2. Provide DC power system including free standing enclosure panel, station batteries with battery rack, and

battery charger. The system shall be suitable for the requirements of the[high voltage circuit breaker][and all other loads indicated]. Batteries shall be [24][48][_____] V, lead-acid,[pasted plate type][or][sealed, totally absorbed electrolyte type]. The DC power system shall be totally compatible with all equipment served. The system shall serve the[high voltage circuit breaker controls,][the low voltage switchboard main circuit breakers' trip system,][the alarm system,][and the emergency lights]. The capacity of the batteries shall be calculated by the high voltage circuit breaker manufacturer and approved by the Contracting Officer before acceptance. The DC panel shall have a hinged lockable front door, main bus, ground bus, circuit breakers, terminal blocks, wiring and cable supports, and AC and DC overcurrent circuit protection. Provide DC load circuit breakers (quantity, ampacity, configuration, and so forth) as indicated on the drawings. The DC power system shall include manual and automatic charger control, a rheostat for DC voltage adjusting, and a DC voltmeter and ammeter. Indicator lamps shall be provided for indicating AC voltage, DC low voltage condition, DC load fed by battery, and DC system failure (an alarm status).[The DC system failure alarm shall be connected to the alarm panel and shall activate this alarm system.] System shall include, but not necessarily limited to, the following:

a. Pasted plate type batteries: Positive plates shall be of the manchester type and negative plates shall have a life equal to or greater than the positive plates. Battery containers shall be heat and impact resistant clear plastic with electrolyte level lines permanently marked on all four sides. A permanent leakproof seal shall be provided between cover and container and around cell posts. Sprayproof vent plugs shall be provided in covers. Sufficient sediment space shall be provided so that the battery will not have to be cleaned out during its normal life. High porosity separators to provide correct spacing between plates shall be provided.

b. Sealed batteries: Provide batteries with leakproof, spillproof electrolyte utilizing highly absorbent material to separate the positive and negative plates. Battery jars shall be hermetically sealed with welded seams. Batteries shall be maintenance-free requiring no watering to be done.

c. Battery charger shall be full-wave rectifier type, utilizing silicon semiconductor devices. Charger shall maintain a float charge of [2.15][___] V per cell and an equalizing charge of [2.33][___] V per cell. An equalizing charge timer shall be provided which operates automatically after an AC power failure of 5 seconds or more. Timer shall be adjustable for any time period up to 24 hours. Timer shall also be capable of being actuated manually. Adjustable float and equalizing voltage potentiometers shall be provided. Charger voltage shall be maintained within plus or minus 1/2 percent from no load to full load with AC line variations of plus or minus 10 percent and frequency variations of plus or minus 5 percent. Provide a DC voltmeter and ammeter with a minimum 90 mm scale and 2 percent accuracy of full scale. Output current shall be limited to 115 percent of rated output current, even down to short circuit of the DC output terminals. Solid state circuit shall have AC and DC transient voltage terminals. AC and DC magnetic circuit breakers shall be provided. Circuit

breakers shall not be overloaded or actuated under any external circuit condition, including recharge of a fully discharged battery and short circuit of the output terminals. Charger shall be capable of continuous operation at rated current at an ambient temperature of 40 degrees C. Output DC current capacity shall match the requirements of the batteries provided.

d. Provide steel battery rack, painted with two coats of acid resistant paint for mounting batteries. Provide lead-plated copper inter-rack connectors and cell numbers with each rack. Secure battery rack such that it can not overturn or be disrupted by lateral forces accompanying a seismic disturbance.

][2.11 ALARM SYSTEM

The alarm system shall be totally compatible with the high voltage circuit breaker and all other associated equipment. Additional spare auxiliary relays furnished with the high voltage circuit breaker may be used for the alarm system as approved by the circuit breaker manufacturer. Coordinate with the circuit breaker manufacturer and provide an integrally designed system. The alarm system shall consist of an alarm panel, audio and visual alarm devices, emergency shutdown switches, emergency auxiliary relay or relays, auxiliary control relay (device 96), all annunciator lamps, associated switches, and all interconnecting circuitry. The system shall provide all functional operations defined herein and in the associated control diagrams included on the drawings. The auxiliary emergency relay(s) and auxiliary control relay shall be mounted in the alarm panel unless such components are integrated with the high voltage circuit breaker. The alarm system shall operate at [24][48][__] VDC and shall be supplied from the DC power system.

2.11.1 Alarm Panel

The alarm panel shall be solid state, permanently energized type, suitable to signal at least the following features (minimum conditions):

a. General electrical failure of the high voltage circuit breaker (protective relays, transformer relays, circuit breaker tripping, and so forth). Transformer alarm features shall include high temperature alarm and high-high temperature shutdown alarm.

b. General failure of battery or battery-charger.

c. Emergency shutdown, manually activated.

2.11.2 The following alarm sequence shall be provided:

a. Alarm Feature: In case of alarm, the alarm horns shall sound and the alarm lights shall flash.

b. Acknowledge Feature: Upon pushing a "silence" push-button switch, the alarm horns shall silence and the flashing lights shall illuminate at steady state.

c. Clear Feature: Upon clearing the alarm conditions, pushing a reset push-button switch shall de-energize the alarm lights.

d. Ringback Feature: The alarm panel shall include "ringback" feature in which the system shall activate in an alarm status should a subsequent alarm be activated after a prior alarm has been "acknowledged".

e. Test Feature: A test push-button shall be provided for testing the alarm horns and alarm lights.

f. Annunciation Features: The alarm panel shall have a panel mounted annunciator lamp which matches the operations of the outdoor alarm light. There shall also be an annunciator lamp for each alarm and status function specified and indicated on the drawings. All lamps and switches shall have nameplates in English and [Italian][_____]. All annunciator lamps shall have a "push to test lamp" feature. A consolidated test system (single test switch with control relay) may be provided in lieu of multiple individual test switches.

][2.12 AUTOMATIC POWER FACTOR COMPENSATING UNIT

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NOTE: Provide automatic power factor compensating (PFC) units when specifically required by the Station/Base. The Aviano Air Base requires PFC units with service transformers. It is customary practice to mount the PFC unit adjacent to the transformer.

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CEI EN 60143-1, CEI EN 60143-2, CEI EN 60143-3, CEI EN 60831-1 and CEI EN 60831-2. Automatic power factor compensating units shall be approved and listed by a recognized European safety organization and shall have a "mark of quality" from such an organization. Automatic power factor compensating units shall be compact, free-standing, steel panel construction complete with capacitor banks, relays for automatic regulation of power factor, equipment circuit breakers or fuses, contactors, control unit with control relay, discharging resistors, terminals, and all accessories necessary to provide a complete and totally automatic operating system. Each unit shall include a fixed capacitor bank to compensate for the transformer's no-load losses. Capacitor banks (fixed type and variable type) shall be sized as indicated on the drawings and shall be provided with discharging resistors sized in accordance with the manufacturer's recommendations. The discharging resistors shall safely discharge the capacitors. Capacitors shall be the oil insulation type and shall contain no PCB's. Equipment circuit breakers shall be provided in accordance with CEI EN 60934. Low voltage fuses shall be provided in accordance with CEI EN 60269-1. The enclosure assembly shall comply with CEI EN 60529 for a dry, interior environment. Provide terminal boards and wiring marking system same as required for low voltage switchgear.

2.12.1 Control Relay

The power factor control relay shall be an automatic regulator with the

following characteristics:

a.	Voltage sensing supply circuit	220/380 Volts, single phase
b.	Voltage circuit consumption	5 VA
c.	Frequency	50 Hz
d.	Current supply circuit	5 Amps, Single phase
e.	Current circuit consumption	0.2 VA
f.	Regulation range of power factor	0.80 to 0.95
g.	Operating temperature	-10 to +60 degrees C

]2.13 INSULATED BARRIERS

Where insulated barriers are required by reference standards, provide barriers with 6 mm minimum thickness.

2.14 FINISH

Exterior surface of the high voltage equipment shall be [light gray][_____][and in accordance with the Station's color selection standards].

2.15 CORROSION PROTECTION

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NOTE: Choose the level of corrosion protection required for the specific project location. Galvanized steel should be the choice in most cases.

****

Bases, frames, and channels of the high voltage equipment which come in contact with concrete shall be corrosion resistant and shall be fabricated of[hot-dip galvanized steel conforming to CEI 7-6][or][stainless steel conforming to UNI EN 10088-1]. Galvanize after fabrication where practicable. Base shall include any part of the unit substation that is within 75 mm of the concrete pad.

2.16 TERMINAL BOARDS

CEI EN 60947-7-1. Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Terminal boards associated with current transformers shall be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification shall be identical in similar units. External wiring shall be color coded consistently for similar terminal boards.

2.17 WIRE MARKING

CEI EN 60947-7-1. Mark control and metering conductors at each end. Provide factory-installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve shall contain a single letter or number, shall be elliptically shaped to securely grip the wire, and shall be keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Each wire marker shall indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.18 NAMEPLATES

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

2.19 WARNING SIGNS

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

2.20 SOURCE QUALITY CONTROL

Provide all tests in accordance with the requirements of the referenced standards of the respective electrical equipment. See paragraph titled, "Manufacturer's Factory Test Schedule".

2.20.1 High Voltage[Switches][Switch Assembly] Design Tests

Provide high voltage design tests on this equipment in accordance with the paragraph entitled "High Voltage Design Tests for Power Equipment".

2.20.2 High Voltage Circuit Breaker Design Tests

Provide high voltage design tests on this equipment in accordance with the paragraph entitled "High Voltage Design Tests for Power Equipment".

2.20.3 High Voltage Design Tests for Power Equipment

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification. Required tests shall be as follows:

a. Dielectric:

    1. Low-frequency withstand

    2. Impulse withstand

b. Continuous current

c. Short-time current withstand (2 - second)

d. Momentary current (10 cycles)

e. Mechanical endurance

f. Insulator Supports

1. Flame-resistance

2. Tracking-resistance

g. Bus-bar insulation

1. Dielectric Strength

2. Flame-resistance

h. Paint qualification

i. Rain

2.20.4 High Voltage[Switches][Switch Assembly] Production Tests

Provide high voltage production tests on this equipment in accordance with the paragraph entitled "High Voltage Production Tests for Power Equipment".

2.20.5 High Voltage Circuit Breaker Production Tests

Provide high voltage production tests on this equipment in accordance with the paragraph entitled "High Voltage Production Tests for Power Equipment".

2.20.6 High Voltage Production Tests for Power Equipment

Furnish reports of production tests performed on the actual equipment for this project. Required tests shall be as follows:

a. Dielectric

b. Mechanical operation

[c. Grounding of instrument transformer case]

[d. Electrical operation and control wiring]

2.20.7 Transformer Design Tests (Liquid Insulated)

CEI EN 60076-3, CEI EN 60076-4, CEI EN 60076-5. Design tests shall be made only on representative apparatus of basically the same design. Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for[each of] the specified transformer(s). Design tests shall have been performed prior to the award of this contract.

a. Tests shall be certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (OA), the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer, if specified. Design lightning impulse tests shall include both the primary and secondary windings of that transformer.

    1. State test voltage levels.

    2. Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" for the lifting and moving devices test means a transformer in the same weight range as the transformer specified.

e. Pressure: "Basically the same design" for the pressure test means a transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

2.20.8 Transformer Routine and Other Tests (Liquid Insulated)

CEI EN 60076-3, CEI EN 60076-4, CEI EN 60076-5. Routine and other tests shall be performed by the manufacturer on[each of] the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence shall be as follows:

a. Cold resistance measurements (provide reference temperature)

b. Phase relation

c. Ratio

d. Insulation power-factor by manufacturer's recommended test method.

e. No-load losses (NLL) and excitation current

f. Load losses (LL) and impedance voltage

g. Dielectric

    1. Impulse: Test the primary winding only.

        (a) State test voltage levels

(b) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test reports.[As an alternative, photographs of oscilloscope display waveforms or plots of digitized waveforms may be hand-delivered at the factory witness test.]

2. Applied voltage

3. Induced voltage

h. Leak

2.20.9 Transformer Design Tests (Dry Type)

CEI EN 60076-3, CEI EN 60076-4, CEI EN 60076-5Design tests shall be made only on representative apparatus of basically the same design. Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for[each of] the specified transformer(s). Design tests shall have been performed prior to the award of this contract.

a. Tests shall be certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (AA), the same temperature rise rating, the same insulating class and the same insulating medium as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary). Design lightning impulse tests shall include both the primary and secondary windings of that transformer.

1. State test voltage levels.

2. Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

3. Partial Discharge Test.

2.20.10 Transformer Routine and Other Tests (Dry Type)

CEI EN 60076-3, CEI EN 60076-4, CEI EN 60076-5. Routine and other tests shall be performed by the manufacturer on[each of] the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence shall be as follows:

a. Resistance measurements

b. Phase relation

c. Ratio

d. Insulation power-factor by manufacturer's recommended test method.

e. No-load losses (NLL) and excitation current

f. Load losses (LL) and impedance voltage

g. Lightning impulse: Perform the complete design type impulse tests on the transformer primary winding only.

1. State test voltage levels

2. Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test reports.[As an alternative, photographs of oscilloscope display waveforms or plots of digitized waveforms may be hand delivered at the factory witness test.]

h. Low frequency dielectric

1. Applied voltage

2. Induced voltage

2.20.11 Low Voltage Switchgear Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification. Required tests shall be as follows:

a. Temperature rise tests

b. Short-circuit current test

c. Enclosure tests

d. Dielectric test

2.20.12 Low Voltage Switchgear Production Tests

Furnish reports which include results of production tests performed on the actual equipment for this project. Perform in accordance with CEI EN 60439-1. Required tests shall be as follows:

a. 50-hertz dielectric test

b. Mechanical operation tests

c. Electrical operation and control wiring tests

d. Ground fault sensing equipment test

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall be as indicated on project drawings and the approved shop drawings; as instructed and recommended by the equipment manufacturers; and as specified herein.

3.2 GROUNDING

****

NOTE: Where rock or other soil conditions prevent obtaining a specified ground value, specify other methods of grounding. Where it is impractical to obtain the indicated ground resistance values, make every effort to obtain ground resistance values as near as possible to the indicated values.

Provide drawing details of all grounding system features including ground rod inspection pits, ground bus bar system (mounted on insulators), equipment ground bars, and other specific grounding system components. Be sure to define the size of all ground conductors.

****

Provide ground system as specified in Section 16303, "Underground Electrical Work". Grounds and grounding systems shall have a resistance to solid earth ground as calculated by CEI 11-1 and CEI 64-8. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" shall apply.

3.2.1 Ground Rods

Provide ground rods as specified in Section 16303, "Underground Electrical Work".

3.2.2 Grounding of Power Equipment

Provide copper conductors as indicated. Conductors shall be bare unless indicated otherwise. Provide all ground connections to the power equipment in accordance with the manufacturers' instructions and recommendations. Exterior ground conductors shall be buried not less than 600 mm below grade and connected to the indicated ground rods.[Transformer neutral connections shall not be smaller than [___] mm^2.][Fence and equipment connections shall not be smaller than 16 mm^2. Ground fence at each gate post and cornerpost and at intervals not exceeding 3000 mm. Bond each gate section to the fence post through a 3 mm by 25 mm flexible braided copper strap and clamps.]

3.2.3 Grounding Connections

Connectors and connections shall be installed as specified in Section 16303, "Underground Electrical Work".

3.2.4 Ground Conductor Crossing Expansion Joints in Structures and Pavements

Protect ground conductors from damage by means of approved devices or installation methods to allow the necessary slack across the expansion joint. Provide stranded (braided) copper strap or other approved flexible copper assembly across such separations.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment, materials and miscellaneous devices furnished under this section as indicated on project drawings, the approved shop drawings, as specified herein, and in accordance with the manufacturers' instructions and recommendations.

3.3.1 Galvanizing Repair

For galvanizing damaged by handling, transporting, cutting, welding, or bolting, repair the damage to galvanized coatings using zinc rich paint provided by the associated equipment manufacturer. Do not heat surfaces that repair paint has been applied to.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

****

NOTE: Define on drawings the specific equipment required to have a concrete mounting slab. Mounting slab connections may have to be given in detail depending on the requirements for the seismic zone in which the equipment is located. Include construction requirements for concrete slab only if slab is not detailed in drawings. Do not provide interior slabs if raceway system is a subsurface cable trench system. Exterior locations are only allowed where specifically required by the Activity. Also, curbs or raised edges may be required around liquid filled transformers. Ensure specification Section 03300 is included in the final contract specifications.

****

3.4.1 Interior Location

Mount indicated equipment on concrete slab. Slab shall be at least 100 mm thick. Top of concrete slab shall be approximately 100 mm above finished floor. Edges above floor shall have 15 mm chamfer. Slab shall be of adequate size to project at least 200 mm beyond the equipment, except that front of slab shall be large enough to serve as a platform to withdraw breakers. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Conduits entering the slab, including the 90 degree elbow fittings, shall be rigid steel conduits. Seal voids around

conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm above slab surface. Concrete work shall be as specified in Section 03300, "Cast-In-Place Concrete".

[3.4.2 Exterior Location

Mount indicated equipment on concrete slab. Slab shall be at least 200 mm thick, reinforced with wire fabric 150 mm square and placed uniformly 100 mm from the top of the slab. Slab shall be placed on a 150 mm thick, well-compacted gravel base. Top of concrete slab shall be approximately 100 mm above finished grade. Edges above grade shall have 15 mm chamfer. Slab shall be of adequate size to project at least 200 mm beyond equipment, except that front of slab shall be large enough to serve as a platform to withdraw breakers. Provide conduit turnups and cable entrance space required by the equipment to be mounted and as indicated. Conduits entering the slab, including the 90 degree elbow fittings, shall be rigid steel conduits. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm above slab surface. Concrete work shall be as specified in Section 03300, "Cast-In-Place Concrete".

]3.5 FIELD QUALITY CONTROL

3.5.1 Performance of Acceptance Checks and Tests

Perform acceptance checks and tests in accordance with Section 16081, "Apparatus Inspection and Testing," the manufacturer's recommendations, referenced standards, and requirements of the host nation. Perform tests specific to high voltage[switches][circuit breakers], power transformers, low voltage switchgear, relays, metering, and instrument transformers.[Provide services of manufacturer's technical representative to perform testing and calibration of protective power relays and associated devices.] Perform tests to obtain information about the performance of breakers, meters, wiring, and instrument transformers together, as well as separately. The Contracting Officer will witness formal tests after receipt of written certification that preliminary tests have been completed and that system is ready for final test and inspection. Tests shall include those listed in the specified equipment's referenced publications and the following paragraphs.

3.5.1.1 High Voltage[Switches][and][Circuit Breaker] Inspection and Tests

Perform in accordance with CEI 17-1, CEI EN 60265-1, CEI EN 62271-102, and CEI EN 60076-5.

a. Visual and Mechanical Inspection

    1. Compare equipment nameplate data with specifications and approved shop drawings.

    2. Inspect physical and mechanical condition.

    3. Confirm correct application of manufacturer's recommended lubricants.

4. Verify appropriate anchorage and required area clearances.

5. Verify appropriate equipment grounding.

6. Verify correct[blade][contactor] alignment, blade penetration, travel stops, and mechanical operation.

[7. Verify that fuse sizes and types correspond to approved shop drawings.]

[8. Verify that each fuse holder has adequate mechanical support.]

9. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic surveying is not required.

10. Test interlocking systems for correct operation and sequencing.

11. Verify correct phase barrier materials and installation.

12. Inspect all indicating devices for correct operation

b. Electrical Tests

1. Perform insulation-resistance tests.

2. Perform over-potential tests.

3. Measure contact-resistance across each[switch blade][contactor][and fuse holder].

[4. Measure fuse resistance.]

5. Verify heater operation.

3.5.1.2 Transformers (Liquid Insulated) Inspection and Tests

Perform in accordance with CEI EN 60076-1, CEI EN 60076-2, CEI EN 60076-3, CEI EN 60076-4, and CEI EN 60076-10.

a. Visual and mechanical inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

[3. Verify that cooling fans and pumps operate correctly and that fan and pump motors have correct overcurrent protection.]

[4. Verify operation of all alarm, control, and trip circuits from temperature and level indicators, pressure relief device, and

fault pressure relay.]

5. Verify tightness of accessible bolted electrical connection by calibrated torque-wrench method. Thermographic survey is not required.

6. Verify correct liquid level in transformer tank.

7. Perform specific inspections and mechanical tests as recommended by manufacturer.

8. Verify correct equipment grounding.

b. Electrical Tests

1. Perform insulation-resistance tests.

2. Perform turns-ratio tests.

3. Perform insulation power-factor/dissipation-factor tests on windings.

4. Sample insulating liquid. Sample shall be tested for:

(a) Dielectric breakdown voltage

(b) Acid neutralization number

(c) Specific gravity

(d) Interfacial tension

(e) Color

(f) Visual condition

(g) Parts per million water

(h) Measure dissipation factor or power factor.

5. Perform dissolved gas analysis (DGA).

6. Test for presence of PCB.

7. Verify that the tap-changer is set at specified ratio.

8. Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.5.1.3 Transformers (Dry Type) Inspection and Test

Perform in accordance with CEI 14-8.

a. Visual and Mechanical Inspection

1. Compare equipment nameplate information with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify that control and alarm settings on temperature indicators are as specified.

[4. Verify that cooling fans operate correctly and that fan motors have correct overcurrent protection.]

5. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is not required.

6. Perform specific inspections and mechanical tests as recommended by manufacturer.

7. Make a close examination for shipping brackets or fixtures that may not have been removed during installation and ensure that resilient mounts are free.

8. Verify that winding core, frame, and enclosure groundings are correct.

9. Verify that as-left tap connections are as specified.

b. Electrical Tests

1. Perform insulation-resistance tests.

2. Perform power-factor tests or dissipation-factor tests in accordance with the test equipment manufacturer's instructions.

3. Perform turns-ratio tests.

4. Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

5. Perform overpotential test on all high- and low-voltage windings-to-ground.

3.5.1.4 Low Voltage Switchgear Inspection and Test

Perform in accordance with CEI EN 60439-1, CEI EN 60439-2, CEI EN 60529, CEI EN 60947-1, CEI EN 60947-2, CEI EN 60947-4-1, CEI EN 60947-5-1, and CEI EN 60947-7-1.

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical, electrical, and mechanical condition.

3. Confirm correct application of manufacturer's recommended lubricants.

4. Verify appropriate anchorage, required area clearances, and correct alignment.

5. Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

6. Verify that[fuse and] circuit breaker sizes and types correspond to approved shop drawings.

[7. Verify that current transformer ratios correspond to approved shop drawings.]

8. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is not required.

9. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

10. Clean the low voltage switchgear.

11. Inspect insulators for evidence of physical damage or contaminated surfaces.

12. Verify correct barrier[and shutter] installation[and operation].

13. Exercise all active components.

14. Inspect all mechanical indicating devices for correct operation.

15. Verify that vents are clear.

16. Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

[17. Inspect control power transformers.]

b. Electrical Tests

1. Perform insulation-resistance tests on each bus section.

2. Perform overpotential tests.

3. Perform insulation-resistance test on control wiring. Do not perform this test on wiring connected to solid-state components.

4. Perform control wiring performance test.

5. Perform primary current injection tests on the entire current

circuit in each section of assembly.

[6. Perform phasing check on parallel connected switchgear to ensure correct bus phasing from each source.]

7. Verify operation of heaters.

3.5.1.5 Low voltage Power Air Circuit Breakers Inspection and Tests

Perform in accordance with CEI EN 60947-2.

a. Visual and Mechanical Inspection

1. Compare nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Confirm correct application of manufacturer's recommended lubricants.

4. Inspect anchorage, alignment, and grounding. Inspect arc chutes. Inspect moving and stationary contacts for condition, wear, and alignment.

5. Verify that all maintenance devices are available for servicing and operating the breaker.

6. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

7. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

8. Verify tightness of accessible bolted bus connections by calibrated torque-wrench method. Thermographic survey is not required.

9. Check cell fit and element alignment.

10. Check racking mechanism.

b. Electrical Tests

1. Perform contact-resistance tests on each breaker.

2. Perform insulation-resistance tests.

3. Adjust breaker(s) for final settings in accordance with Government provided settings.

4. Determine long-time minimum pickup current by primary current injection.

5. Determine long-time delay by primary current injection.

****
NOTE: Coordinate each option with each breaker type.
****

[6. Determine short-time pickup and delay by primary current injection.]

[7. Determine ground-fault pickup and delay by primary current injection.]

[8. Determine instantaneous pickup value by primary current injection.]

[9. Activate auxiliary protective devices, such as under-voltage relays, to ensure operation of shunt trip devices. Check the operation of electrically-operated breakers in their cubicle.]

10. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

11. Check charging mechanism.

3.5.1.6 Compact (Molded Case) Circuit Breakers Inspection and Tests

Perform in accordance with CEI EN 60947-2.

a. Visual and Mechanical Inspection

1. Compare nameplate data with specifications and approved shop drawings.

2. Inspect circuit breaker for correct mounting.

3. Operate circuit breaker to ensure smooth operation.

4. Inspect case for cracks or other defects.

5. Verify tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method. Thermographic survey is not required.

6. Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests for All Compact Circuit Breakers

1. Perform contact-resistance tests.

2. Perform insulation-resistance tests.

[c. Electric Tests for Compact Circuit Breakers with Solid State Trip Units

1. Adjust Breaker(s) for final settings.

2. Perform long-time delay time-current characteristic tests

****
NOTE: Coordinate each option with each breaker type.
****

3. Determine short-time pickup and delay by primary current injection.]

[4. Determine ground-fault pickup and time delay by primary current injection.]

[5. Determine instantaneous pickup current by primary injection.]

[6. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.]

3.5.1.7 Current Transformers[and Voltage Transformers] Inspection and Tests

Perform in accordance with CEI EN 60044-1[and CEI EN 60044-2].

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify correct connection.

4. Verify that adequate clearances exist between primary and secondary circuit.

5. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is not required.

6. Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

1. Perform insulation-resistance tests.

2. Perform polarity tests.

3. Perform ratio-verification tests.

3.5.1.8 Metering and Instrumentation Inspection and Tests

Perform in accordance with CEI EN 61010-1.

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify tightness of electrical connections.

b. Electrical Tests

1. Determine accuracy of meters.

2. Calibrate meters according to manufacturer's published data.

3. Verify all instrument multipliers.

4. Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.9 [DC Power System,][Alarm System][and Automatic Power Factor Compensating Unit]Inspection and Tests

****
NOTE: Edit references to match the system(s) specified for the project.
****

Perform in accordance with[CEI EN 60831-1,][CEI EN 60831-2,][CEI EN 60896-2,][CEI EN 60143-1,][CEI EN 60143-3,][and][CEI UNI EN 45510-2-3].

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical, electrical, and mechanical condition.

3. Verify appropriate anchorage, required area clearances, and correct alignment.

4. Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

5. Verify that fuse and circuit breaker sizes and types correspond to approved shop drawings.

6. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is not required.

7. Confirm correct operation and sequencing of the equipment.

8. Clean the equipment.

9. Exercise all active components.

10. Inspect all measuring and indicating devices for correct operation.

b. Electrical Tests

1. Perform electrical tests recommended by the equipment manufacturer[s].

3.5.1.10 Grounding System

a. Visual and Mechanical Inspection

1. Inspect ground system for compliance with contract plans and specifications.

b. Ground Resistance Tests

1. Electrical tests shall be as defined in Section 16303, "Underground Electrical Work".

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function.[Circuit breakers shall be tripped by operation of each protective device.] Test shall require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, the Contracting Officer shall be given[5][10] working days' advance notice of the dates and times for checks, settings, and tests.

-- End of Section --