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

IGS-16430 (April 2004)

Based on UFGS 16442N (7/99)
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SECTION IGS-16430

LOW VOLTAGE SWITCHGEAR AND CONTROLGEAR
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.
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NOTE: This guide specification covers the requirements for free standing low voltage switchgear and controlgear (LVSG) and which is not directly connected to any other electrical equipment such as a transformer. This guide specification also covers automatic power factor compensating units. LVSG equipment is also used to fulfill motor control functions. This equipment is frequently used in commercial buildings at 600 volts and below for service entrance, power, or lighting distribution. If the LVSG is connected to a high voltage/low voltage prefabricated substation, then use Section 16364, "High Voltage/Low Voltage Prefabricated Substations". Specify interior LVSG unless the project's activity specifically requires outdoor equipment. In such cases, obtain the activity's construction standards and requirements.

It is customary European practice to use LVSG equipment as automatic transfer switching functions, including the application with diesel engine generator sets. However, do not use this specification for automatic transfer purposes. Instead, use Section 16410, "Automatic Transfer Switch". It is standard DOD practice to use separate, dedicated automatic transfer switches for ease of operation and maintenance.

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

Use of electronic communication is encouraged.

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

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

1. Single-line diagram showing buses and interrupting devices with interrupting capacities; current transformers with ratings; instruments and meters required; description of instruments and meters; and description of all motor control features (if any).

2. Location, space available, arrangement, and elevations of each LVSG.

3. Grounding system plan and details including ground conductor size.

4. Type and number of cables, size of conductors, conduits, for each power and control circuit, and point of entry (top, bottom, or side).

5. 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 64-8	(1998; Amend 2001) Electrical Installations of Buildings
CEI EN 60044-1	(2000) Instrument Transformers Part 1: Current Transformers
CEI EN 60099-4	(1998) Surge Arresters. Part 4: Metal-Oxide Surge Arresters without Gaps for A.C. Systems
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 60269-1	(2000) Low-Voltage Fuses Part 1: General Requirements
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) 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 60831-1	(1997) 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 60934	(2002) Circuit Breakers for Equipment (CBE)
CEI EN 60947-1	(2000) Low-Voltage Switchgear and Controlgear - Part 1: General Rules
CEI EN 60947-2	(1998) 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) Low-Voltage Switchgear and Controlgear Part 5-1: Control Circuit Devices and Switching Elements Electromechanical Control Circuit Devices
CEI EN 60947-7-1	(1998) Low-Voltage Switchgear and Controlgear. Part 7: Ancillary Equipment. Section One: Terminal Blocks for Copper Conductors
CEI EN 61010-1	(2001; Errata Corrige 2002) Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use Part 1: General Requirements

ITALIAN LAWS AND NORMS

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

ITALIAN NATIONAL ASSOCIATION FOR THE UNIFICATION OF STANDARDS (UNI)

UNI EN ISO 1461	(1999) Hot Dip Galvanized Coatings on Fabricated Iron and Steels Articles - Specifications and Test Methods
UNI 9866	(1991) Paints and Varnishes. Zinc-Rich Inorganic Primers. Requirements for the Identification and the Characterization
UNI 9867	(1991) Paints and Varnishes. Zinc-Rich Inorganic Primers. Requirements for the Identification and the Characterization

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 low voltage switchgear material or components are specified in Section 16303, "Underground Electrical Work" and Section 16402, "Interior Distribution System."

1.3 DEFINITIONS

1.3.1 Host Nation

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

1.3.2 Low Voltage Switchgear and Controlgear

Low voltage switchgear and controlgear are totally enclosed, free-standing electrical structures specifically designed as electrical service entrance equipment, or as electrical distribution centers, or as motor control centers, or as a combination of these three functions. They are commonly referred to as "low voltage switchgear" or "distribution switchboards".

1.4 SUBMITTALS

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

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Submit the following in accordance with Section 01330, "Submittal Procedures".

SD-02 Shop Drawings

Low Voltage Switchgear and Controlgear Drawings; G

[Automatic Power Factor Compensating Units Drawings; G]

SD-03 Product Data

Low Voltage Switchgear and Controlgear; G

[Automatic Power Factor Compensating Units; G]

Circuit breakers, including adjustable trip features; G

[Fuses; G]

Motor control equipment; G

Meters; G

Instrument transformers; G

Switchgear Paint Qualification Test

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", 16302N, 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

Switchgear Paint Qualification Test; G

SD-07 Certificates

Manufacturer's Factory Test Schedule

[Motor and Equipment Load Coordination; G]

SD-08 Manufacturer's Instructions

Low Voltage Switchgear and Controlgear Instructions; G

[Automatic Power Factor Compensating Units Instructions; G]

Meters and Instrument Transformers Instructions; G

SD-09 Manufacturer's Field Reports

Switchgear Design and Production Tests; G

SD-10 Operation and Maintenance Data

Switchgear and Controlgear Operation and Maintenance Data, Data Package 5; G

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals; G

Equipment Test Schedules; G

Request for Settings; G

1.5 QUALITY ASSURANCE

1.5.1 Low Voltage Switchgear and Controlgear Drawings

Submittals shall show sectional views of cubicles. Provide manufacturer's instruction manuals for all protective power features and associated

devices [and metering equipment], including instructions of how to set and operate all components. Submittals shall include data on circuit breakers, [fuses,] [motor-control features,] [meters and instrument transformers,] and all associated accessories including adjustable trip features. Drawings shall include, but are not limited to the following:

a. One-line diagram including breakers[, fuses][, current transformers, and meters]

b. Outline drawings including front elevation, section views, footprint, and overall dimensions

c. Bus configuration including dimensions and ampere ratings of bus bars

d. Markings and NEMA nameplate data[, including fuse information (manufacturer's name, catalog number, and ratings)]

e. Circuit breaker type, interrupting rating, and trip devices, including available settings

f. Three-line diagrams and elementary diagrams and wiring diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (on full size logarithmic paper) of the main secondary breaker and largest secondary feeder device. These shall be used by the designer of record to provide breaker settings that will ensure protection and coordination are achieved.

[h. Provisions for future extension.]

1.4.1 Low Voltage Switchgear and Controlgear Product Data

Each submittal shall include manufacturer's information for each component, device and accessory provided with the switchgear and controlgear including:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings

b. Manufacturer's instruction manuals and published time-current curves (on full size logarithmic paper) of the main secondary breaker and largest secondary feeder device.

[1.5.3 Automatic Power Factor Compensating Units 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.

][1.5.6 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.

]1.6 MAINTENANCE

1.6.1 Switchgear and Controlgear Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section 01781, "Operation and Maintenance Data".

1.6.2 Assembled Operation and Maintenance Manuals

Manuals shall be assembled and binded securely in durable, hard covered, water resistant binders. The manuals shall be assembled and indexed in the following order with a table of contents. The contents of the assembled operation and maintenance manuals shall be as follows:

a. Manufacturer's O&M information required by the paragraph entitled "SD-10, Operation and Maintenance Data".

b. Catalog data required by the paragraph entitled, "SD-03, Product Data".

c. Drawing required by the paragraph entitled, "SD-02, Shop Drawings".

d. Prices for spare parts and supply list.

[e. Information on metering]

f. Design test reports

g. Production test reports

PART 2 PRODUCTS

2.1 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
Viale dell' Industria 2
36057 Arcunano (VI)
Tel: (39) 444 963990
Fax: (39) 444 961551
gemmo@gemmo.com

2.2 GENERAL REQUIREMENTS

2.2.1 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 Marking (Conformite Europeenne Mark). The CE Marking logo shall be placed on the product, the product literature, and/or packaging as required by the respective EU directive, or directives.

2.2.2 Factory Assembly

Low voltage switchgear and controlgear shall be factory assembled by an electrical manufacturer or fabricator who is regularly engaged in the dedicated construction of low voltage switchgear and controlgear. Switchgear assembly by the Contractor in the field or in his shop shall not be acceptable.

2.3 PRODUCT COORDINATION

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

2.4 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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2.4.1 Ratings

CEI EN 60439-1. Low voltage switchgear shall be approved and listed by a recognized European safety organization and shall have a "marking 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 50,000 or [_____] 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. Each compartment shall have a separate hinged door. Circuit breaker operating handles shall extend through the compartment door. Switchgear shall be completely factory engineered and assembled including protective devices, interconnections, instruments and control wiring. Switchgear shall consist of incoming main circuit breaker section and distribution sections as indicated. Low voltage switchgear shall be completely factory engineered and assembled and tested, 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.

2.4.2 Low Voltage Switchgear 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.

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CEI EN 60947-1. Low voltage switchgear type[s] required for this project include [main service low voltage switchgear] [and] [distribution low voltage switchgear]. Switchgear shall be provided as indicated on the drawings and as specified in this specification.

2.4.2.1 Main Service 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 unit 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.]

2.4.2.2 Distribution Low Voltage Switchgear

Switchgear shall include front access only. 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.]

2.4.2.3 Construction

Switchgear shall consist of vertical sections bolted together to form a rigid assembly and shall be [rear] [front and rear] aligned [as indicated]. All circuit breakers shall be front accessible. [Rear aligned switchgear shall have front accessible load connections.] [Front and rear aligned switchgear shall have rear accessible load connections.] [Compartmentalized switchgear shall have vertical insulating barriers between the front device section, the main bus section, and the cable compartment[with full front to rear vertical insulating barriers between adjacent sections].] Where indicated, "space for future" or "space" shall mean to include bus, device supports, and connections. Provide insulating

barriers. Apply moisture resistant coating to all rough-cut edges of barriers.

2.4.2.4 Enclosure

Provide low voltage switchgear for outdoor, indoor, or explosive environments, in accordance with CEI EN 60529.

2.4.3 Bus Bars

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NOTE: Use copper with silver-plated contact surfaces in exterior or damp locations or for heavy motor loads.
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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[, with 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. Mount bus structure on insulated supports of high-impact, non-tracking, high-quality insulating material. Brace bus structure to withstand mechanical forces exerted during short circuit conditions when connected directly to a source having maximum of 50,000 amperes rms symmetrical short circuit current available. Provide and secure ground bus to each vertical section and extend ground bus the entire length of the structure. Equip ground bus with a terminal for connection to the service ground. Bus bars shall be rated for [800] [1250] [1600] [2000] amperes. Neutral bus shall be rated [100] [___] percent of the main bus as indicated. Insulate cable and bus components. Connect bus bars from main buses to the incoming circuit breaker studs. Provide cable supports for outgoing cables. Isolate cable compartments from bus compartments.

2.4.4 Main Section

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.

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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.
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[2.4.4.1 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 trip device 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] tripping 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.

][2.4.4.2 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. Settings shall be located behind cover to deter tampering. [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.

]2.4.5 Distribution Section

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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.

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.

][2.4.5.1 Solid-State Trip Devices

[Where specifically indicated, circuit breakers] [Circuit breakers] 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 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 adjustable ground fault protection integral with the solid-state trip device.]

][2.4.5.2 Circuit Breaker Handles for Individually Mounted Devices

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.

]2.4.6 Motor Control Equipment

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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.

i. Provide instrument transformers for motor control equipment.

2.4.6.1 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. Comply with all instructions and recommendations of the associated equipment manufacturers.

2.4.6.2 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.

2.4.6.3 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.

2.4.6.4 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 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's 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.)

2.4.6.5 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.

2.4.6.6 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 UFC 3-520-01, "Interior Electrical 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.

2.4.7 Digital Multimeters for Electrical Metering

****

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 switchgear 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. Digital meters shall comply with CEI EN 61010-1 and surge requirements of CEI EN 60099-4. Meter shall be electronic type indicating amperes and volts. Amps shall be indicated for L1, L2 and L3. Volts shall be indicated for L1-L2, L2-L3 and L1-L3. 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 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.

2.4.7.1 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.

[2.4.7.2 Digital Meters, 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.]

2.4.7.3 Terminal Blocks

CEI EN 60947-7-1. All field wiring that serves a metering circuit shall be terminated in a dedicated terminal block.

][2.4.8 Watthour Meters

****

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

****

CEI EN 61010-1. Provide a switchgear 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.
****

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.

]2.4.9 Current Transformers

****
NOTE: Select C.T. accuracy in accordance with the manufacturer's written instructions and recommendations. Indicate ratios on drawings.
****

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 1kV.

[2.4.10 Heaters

Provide 220 volt heaters in each low voltage switchgear section. Heaters shall be of sufficient capacity to control moisture condensation in the section, shall be 250 watts minimum, and shall be controlled by a thermostat [and humidistat] located in each section. Thermostat shall be the industrial type, high limit, designed to maintain each section within the temperature range of 15 to 32 degrees C. [Humidistat shall have a

range of 30 to 60 percent relative humidity.] Heaters shall be electrically served directly from the low voltage switchgear utilizing circuit breakers provided in accordance with CEI EN 60934. [Energize each electric heater while the equipment is in storage and prior to being placed in service. Provide method for easy connection of heater to external power source.]

]2.4.11 Corrosion Protection

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NOTE: Choose the level of corrosion protection required for the specific project location. Use galvanized steel in most indoor applications. Use stainless steel bases for most outdoor applications. In less corrosive environments, galvanized steel can be included as an alternative to stainless steel. Manufacturer's standard construction material is acceptable only in noncoastal and noncorrosive environments.

****

UNI EN ISO 1461 coating as applicable. Galvanize after fabrication where practical. Bases, frames and channels of low voltage switchgear shall be corrosion resistant and shall be fabricated of [stainless steel] [or] [galvanized steel]. Base shall include any part of low voltage switchgear that is within 75 mm of concrete pad. Paint low voltage switchgear, including bases, light gray. Provide switchgear paint qualification test reports showing that the paint qualifications test of UNI EN ISO 1461 has been performed to ensure the adequacy of finishes to inhibit the build-up of rust on ferrous metal materials used for enclosures.

2.4.12 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.

2.4.13 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.

[2.5 AUTOMATIC POWER FACTOR COMPENSATING UNITS

****
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 transformer, low voltage switchgear, and the PFC unit adjacent to one another in a common electrical room.
****

CEI EN 60143-1, CEI EN 60143-2, CEI EN 60143-3 and CEI EN 60831-1. 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, 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.

2.5.1 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

]2.6 NAMEPLATES

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

2.7 WARNING SIGNS

Provide as specified in Section 16050 , "Basic Electrical Materials and Methods". Provide in accordance with D.P.R. 547 and LAW 46.

2.8 SOURCE QUALITY CONTROL

Provide all tests in accordance with the requirements of the referenced standards of the respective electrical equipment.

2.8.1 Manufacturer's Factory Test Schedule

The Government reserves the right to witness all factory tests of the low voltage switchgear and controlgear. Submit Switchgear Design and Production Tests schedule. 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 testing laboratory.

(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.

2.8.2 Low Voltage Switchgear Design and Production Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification. Furnish reports which include results of production tests performed on the actual equipment for this project. Test in accordance with CEI EN 60439-1. Required tests shall be as follows:

a. Design Test

(1) Temperature rise tests

(2) Short-circuit current test

(3) Enclosure tests

(4) Dielectric test

b. Production Test

(1) 50-hertz dielectric test

(2) Mechanical operation tests

(3) Electrical operation and control wiring tests

(4) 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. Provide in accordance with CEI EN 60439-1.

3.2 GROUNDING

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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. Engineer shall calculate resistance values and insert in bracket.

****

Provide grounding system in accordance with Section 16303, "Underground Electrical Work". Grounds and grounding systems shall have a resistance to solid earth ground of [_____] [calculated in accordance with CEI 64-8 as per distribution system provided (TN or TT distribution system)]. 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 and Bonding of Power Equipment

Provide all ground connections as indicated on drawings and in accordance with the manufacturer's instructions and recommendations.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect the low voltage switchgear [and automatic power factor compensating units] furnished under this section as indicated on project drawings, the approved shop drawings, as specified herein, and as instructed and recommended by the equipment manufacturer[s].

3.3.1 Low Voltage Switchgear and Controlgear Instructions

Install in accordance with the instructions and recommendations of the equipment manufacturer.

[3.3.2 Automatic Power Factor Compensating Units Instructions

Install in accordance with the instructions and recommendations of the equipment manufacturer.

][3.3.3 Meters and Instrument Transformers Instructions

Install in accordance with the instructions and recommendations of the equipment manufacturer.

]3.3.4 Galvanizing Repair

UNI 9866 and UNI 9867 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 LOW VOLTAGE SWITCHGEAR AND CONTROLGEAR

****

NOTE: 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 Station/Base.

****

3.4.1 Interior Location

Mount switchgear on concrete slab. Unless otherwise indicated, the slab shall be at least 100 mm thick. The top of the concrete slab shall be approximately 100 mm above finished floor. Edges above floor shall have a 15 mm chamfer. The slab shall be of adequate size to project at least 200 mm beyond the equipment. 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 switchgear on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm thick. All slabs shall be reinforced with a wire mesh (150 mm by 150 mm) placed uniformly 100 mm from the top of the slab. Slab shall be placed on a 150 mm thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm above the finished grade. Edges above grade shall have a 15 mm chamfer. The slab shall be of adequate size to project at least 200 mm beyond the equipment. 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".

]3.5 FIELD QUALITY CONTROL

Contractor shall submit request for settings of breakers to the Contracting Officer after approval of switchgear and at least 30 days in advance of their requirement.

3.5.1 Performance of Acceptance Checks and Tests

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

3.5.1.1 Low Voltage Switchgear and Controlgear Inspection and Tests

Perform in accordance with CEI EN 60439-1 and CEI EN 60947-1.

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) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

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

(10) Clean switchgear after the room has been completely finished and cleaned.

(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 double-ended and parallel operated low voltage switchgear to ensure correct bus phasing from each source.]

[(7) Verify operation of low voltage switchgear heaters.]

[3.5.1.2 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) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(9) Verify cell fit and element alignment.

(10) Verify racking mechanism.

b. Electrical Tests

(1) Perform contact-resistance tests on each breaker.

(2) Perform insulation-resistance tests.

(3) Adjust breakers 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) Verify operation of charging mechanism.

(12) Perform ground-impedance measurements utilizing the fall-of-potential method. ON systems consisting of interconnected ground rods, perform test after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof

(13) 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 conditions at the time the measurements were made.

]3.5.1.3 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) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

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

[b. Electrical Tests for Breakers With Solid-State Trip Units

(1) Perform contact-resistance tests.

(2) Perform insulation-resistance tests.

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

(4) Perform long-time delay time-current characteristic tests.

(5) Determine short-time pickup and delay by primary current injection.

(6) Determine ground-fault pickup and time delay by primary current injection for applicable breakers.

(7) Determine instantaneous pickup current by primary current injection for applicable breakers.

(8) 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.]

3.5.1.4 Current Transformers Inspection and Tests

Perform in accordance with CEI EN 60044-1.

a. Visual and Mechanical Inspection

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

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and

secondary circuit.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

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

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

3.5.1.5 Metering and Instrumentation Inspection and Tests

Perform in accordance with CEI EN 61010-1 and CEI EN 60099-4.

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 at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watthour meters according to manufacturer's published data.

(3) Electrically confirm that current transformer and voltage secondary circuits are intact.

[3.5.1.6 Automatic Power Factor Compensating Units Inspection and Tests

Perform in accordance with CEI EN 60143-1, CEI EN 60143-2, CEI EN 60143-3, and CEI EN 60831-1.

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) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(8) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

(9) Clean the equipment after the room has been completely finished and cleaned.

(10) Inspect insulators for evidence of physical damage or contaminated surfaces.

(11) Exercise all active components.

(12) Inspect all mechanical indicating devices for correct operation.

(13) Verify that vents are clear.

b. Electrical Tests

(1) Perform control wiring performance test.

(2) Perform capacitors performance test as instructed by the capacitor's manufacturer.

(3) Perform other electrical test instructed and recommended by the manufacturer of the automatic power factor compensating units.

]3.5.1.7 Grounding System Inspection and Tests

Perform in accordance with CEI EN 60044-1.

a. Visual and Mechanical Inspection

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

b. Electrical Tests

****
NOTE: Choose first paragraph if ground tests are specified in Section 16303, "Underground Electrical Work".
****

(1) Perform electrical test including resistance tests as specified in Section 16303, "Underground Electrical Work."

(1) 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.

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 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --