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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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SECTION 26 35 33.00 40

POWER FACTOR CORRECTION EQUIPMENT
08/19

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NOTE: This guide specification covers the requirements for metal-enclosed shunt capacitor equipment. Ensure drawings show voltage and kilovar ratings and mounting and connection details.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

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

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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PART 1 GENERAL

1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also

use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2023) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A480/A480M	(2023) Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A1008/A1008M	(2021a) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
ASTM B187/B187M	(2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 18	(2012) Standard for Shunt Power Capacitors
IEEE C2	(2023) National Electrical Safety Code

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 810	(1995; Reprint Aug 2014) UL Standard for Safety Capacitors

1.2 SUBMITTALS

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NOTE: Review Submittal Description (SD) definitions

in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication Drawings; G[, [____]]

Installation Drawings; G[, [____]]

SD-03 Product Data

Metal-Enclosed Shunt Capacitor Equipment; G[, [____]]

Pole Line Capacitors; G[, [____]]

Metal-Enclosed Low-Voltage Capacitors; G[, [____]]

SD-06 Test Reports

Factory Test Report; G[, [____]]

Acceptance Test Report; G[, [____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.3.2 Qualifications

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

1.3.3 Predictive Testing and Inspection Technology Requirements

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NOTE: The Predictive Testing and Inspection (PT&I) tests prescribed in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS are MANDATORY for all NASA assets and systems identified as Critical, Configured, or Mission Essential. If the system is non-critical, non-configured, and not mission essential, use sound engineering discretion to assess the value of adding these additional test and acceptance requirements. See Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS for additional information regarding cost feasibility of PT&I.

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This section contains systems and equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems installed by the Contractor have been installed properly and contain no identifiable defects that shorten the design life of a system and its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work.

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle and store equipment in accordance with manufacturer's instructions. Deliver materials to site in unopened cartons or bundles as appropriate, clearly identified with manufacturer's name, Underwriter's or other approved label, grade or identifying number.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide Power Factor Correction (PFC) equipment as a self-contained, [automatically and]manually-controlled self-protecting capacitor bank [in self contained enclosure][modified for the specified enclosure construction]. Ensure the equipment allows [automatic or]manual switching of the capacitor bank kilovolt ampere reactive (kVAR) in minimum of [25][50][ ] kVAR per step for a total of [three][twelve][twenty-four][ ] steps when fully expanded to the total capacity from or to the bus for power factor correction. Connect the PFC equipment to the switchgear with cable connection through a separate circuit breaker.

2.2 FABRICATION

2.2.1 Drawings

Submit fabrication drawings for the fabrication and assembly performed in the factory. Ensure drawings show all connections and detail the relations and connections of the equipment by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

2.2.2 Corrosion Prevention

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NOTE: For all outdoor applications and all indoor applications in a harsh environment refer to Sections 09 96 00 HIGH-PERFORMANCE COATINGS or 09 90 00 PAINTS AND COATINGS. High performance coatings are specified for all outdoor applications because ultraviolet radiation will break down most standard coatings, causing a phenomena known as chalking, which is the first stage of the corrosion process. For additional information contact The Coatings Industry Alliance, or specific suppliers such as Keeler and Long and PPG, and NACE International (NACE).

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Protect metallic materials against corrosion. Ensure equipment has the standard finish by the manufacturer when used for most indoor installations. For harsh indoor environments (any area subjected to chemical and/or abrasive action), and all outdoor installations, refer to Section [09 96 00 HIGH-PERFORMANCE COATINGS][09 90 00 PAINTS AND COATINGS].

2.3 EQUIPMENT

Submit catalog data and equipment and performance data for the following items including life, test, system functional flows, safety features, and mechanical automated details.

[2.3.1 Metal-Enclosed Shunt Capacitor Equipment

Ensure metal-enclosed shunt capacitor equipment for connection to 2,400-, 6,900-, and 13,200/13,800-volt, three-phase, 60-hertz circuits consists of a complete assembly of capacitor units including buses, connectors, current-limiting fuses, ventilating fans, switching devices, and controls housed in a weatherproof NEMA [3R][4X] metal enclosure in accordance with IEEE 18. Provide control and protective devices in accordance with Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

Provide capacitor units consisting of [self-healing]polypropylene film and aluminum foil sections with series-parallel connections and discharge resistors contained in hermetically sealed welded steel cases with mounting flanges, immersed in a nonflammable liquid dielectric impregnant. Provide capacitor housings constructed with bonded zinc-coated steel that is resistant to corrosion, weather, and abrasion. Seal two insulating bushings with clamp tunnel connectors to the case of each unit, electrically connected to the capacitor section assembly. Ensure capacitors comply with UL 810 and NFPA 70 and characteristics of capacitor bushings are in accordance with IEEE 18. Provide discharge resistors that reduce the residual voltage of the capacitor unit to [50][_____] volts or less within 5 minutes after disconnection from the source of supply. Each capacitor has an individual insulating fuse. Ensure capacitors operate satisfactorily at 135 percent of rated kVAR, 110 percent of rated voltage, and at ambient temperatures between minus 40 degrees to plus 46 degrees C minus 40 degrees to plus 115 degrees F. Ensure voltage and kVAR ratings for enclosed outdoor capacitor units rated at 60-hertz is in accordance with IEEE 18.

Ensure that capacitors for harmonic filter application or systems with high harmonic content have the following characteristics: EXTREME duty rating 55 degree C, 131 degree F temperature rating, 125 percent continuous over-voltage capability, 15kA fault handling capability, 100KA transient current withstand capability, and meets IEEE 18.

For power entrance compartments, include an insulated phase and neutral bus, a short-circuiting and grounding switch, and provisions for terminating underground cables.

Mechanically interlock short-circuiting and grounding switch with all capacitor compartment doors to prevent access to capacitor units unless phase and neutral buses are short circuited and grounded. Provide a key-interlocked short-circuiting and grounding switch with a remote circuit disconnecting and protective device to ensure the proper sequence of operation.

][2.3.2 Pole Line Capacitors

Ensure pole line capacitors are power line, power factor connection type for 2.4 kilovolts (kV), 5 kV, and 13.2/13.8 kV, 60 hertz; located and installed as indicated. Provide pole supporting hardware that is hot-dip galvanized steel designed for NEMA standard capacitor units. Use

corrosion resistant attachment hardware. Ensure poles supporting capacitors are greater than 200 millimeter 8 inches in diameter at the point of attachment.

][2.3.3 Metal-Enclosed Low-Voltage Capacitors

Provide metal-enclosed capacitors for 600-volt circuits and below consisting of individual enclosed units with insulators, connectors, and hardware housed in a protective enclosure. Ensure individual cells are fused and provided with discharge resistors to reduce voltage to 50 volts or less in 1 minute. Include a current-limiting air-core inductor designed to limit the capacitor in-rush current to a value equal to or less than the capacitor switching rating. Brace inductors to withstand symmetrical short circuit current as indicated.

Ensure capacitor cells are of the self-healing type utilizing a low-loss metalized polypropylene film dielectric system with a UL-recognized pressure sensitive interrupter in each capacitor cell and are impregnated with a nonflammable (PCB-free) dielectric. Ensure capacitors comply with UL 810 and NFPA 70. Provide capacitor units in banks with welded, zinc coated, 1.6 millimeter, 14 gauge, steel. Use steel in accordance with ASTM A1008/A1008M. All other requirements are as required for high-voltage installation.

]2.4 COMPONENTS

2.4.1 Enclosure

Place pad-mounted capacitor equipment in weatherproof, self-supporting, ventilated unit sheet metal compartments joined together to form a continuous structure with hinged access doors, base and roof sections, roof seam covers, and end trims. Provide flanged access doors that close against rubber or similar weatherproof gasketing material. Provide ventilated openings with filtered louvers and stainless steel screened vents. Equip doors with latches, stops, and door-locking mechanism. Ensure base section is unit construction and supports capacitor equipment[102 millimeter 4 inches][152 millimeter 6 inches] above the concrete foundation. Design the base for jacking and skidding. Provide lifting lugs for unloading and moving equipment.

Construct sheet metal enclosures from [cold-rolled carbon-steel sheets of commercial quality with stretcher-level flatness not less than two (2.0) millimeter 12 gauge, in accordance with ASTM A1008/A1008M][[304][316] stainless steel in accordance with ASTM A240/A240M and ASTM A480/A480M as applicable]. Reinforce each compartment with structural members and weld members together. Grind welds to a smooth flat surface before painting. Provide capacitor equipment with a ground terminal for grounding the stationary structure and equipment.

Provide capacitor compartments with racks for mounting individual capacitor units in one, two, or three tiers, with not more than two rows of units per tier. Enclosures having one row of units per tier are accessible from one side only.

2.4.2 Buses

Provide phase and neutral buses for the connection to cables and capacitor units are bare rigid solid copper busbar of rectangular cross section, insulated from the enclosure. Ensure busbars are of ASTM B187/B187M solid copper and the contact surfaces of all main bus and cable tap connections

are silver plated and bolted together to ensure maximum conductivity.

2.4.3 Fuses

Ensure each capacitor unit is individually fused with current-limiting fuses that have an short-circuit interrupting rating of 200,000 amperes minimum and provide visual indication of fuse operation.

2.4.4 Fans

Provide top of capacity compartments with thermostatically controlled fans for forced-air ventilation of capacitor units. Provide each enclosure section with two cooling fans. Select [115-volt][277-volt], single-phase, 60-hertz current fan motors that are individually fused or thermally protected. Ensure thermostats control the operation of fans within prescribed temperature limits.

2.5 FACTORY TESTING

Factory production tests on capacitor equipment include electrical and mechanical operational tests, capacitance tests, discharge resistor tests, leak tests, and dielectric strength tests. Ensure factory conducts dielectric tests in accordance with Testing Standards of IEEE 18 with 60-hertz withstand voltage rating equal to that of the switching device.

Certified copies of previous tests on similar equipment under actual conditions may be submitted for impulse tests, and short-circuit tests in lieu of factory tests on actual units furnished.

Submit factory test report containing results of all factory production tests.

PART 3 EXECUTION

3.1 INSTALLATION

Install and connect capacitor equipment in accordance with the manufacturer's installation instructions. Ensure proper ventilation is provided around all equipment.

Make ground connections to a driven ground rod or counterpoise, as indicated.

Submit installation drawings for the capacitor equipment. Include in drawings details of equipment [area][room] layout and design.

3.2 FIELD QUALITY CONTROL

3.2.1 Acceptance Testing

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NOTE: If the specified system is identified as critical, configured, or mission essential, use Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS to establish predictive and acceptance testing criteria, above and beyond that listed below.

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Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

[Disconnect main bus of high-voltage capacitor equipment from the circuit cables, and ground the capacitors and the equipment enclosure before conducting insulation and high-voltage tests.

] For the main bus of capacitor equipment, conduct an insulation-resistance test with a 5000-volt insulation test set for units 5 KV and above, 2,500-volt insulation-resistance test set for units 2.4 kV to 5 kV, and 1,000 volts for units 600 volts and below.

Apply tests for not less than 5 minutes and until three equal consecutive readings, 1 minute apart, are obtained. Record readings every 30 seconds during the first 2 minutes and every minute thereafter. Minimum acceptable resistance is 100 megohms.[

Upon satisfactory completion of the insulation-resistance test, subject main bus to a high-voltage DC (Hi-pot) test. Use a test voltage is equal to 75 percent of the factory test values and apply for 1 minute.]

Upon satisfactory completion of all bus testing, confirm the capacitor's value by performing a capacitance value test. Discharge the capacitor and measure the capacitance per the manufacturer's instructions. Satisfactory measurement is between 100 percent and 110 percent of nameplate. Values between 90 percent and 100 percent, and 110 percent and 120 percent require investigation. Values outside these limits indicate shorted groups of internal layers and the capacitor is considered defective.

Upon satisfactory completion of the capacitance test, subject the capacitor to a dielectric strength test using a DC voltage of 75 percent of the original factory test voltage. Test voltage should be held for 10 seconds. During application of test voltage listen for any indication of internal arcing. If any arcing is heard the unit is defective.

Upon satisfactory completion of the dielectric test, remeasure the capacitance of the capacitor to insure no damage had occurred during the dielectric test. Results cannot vary more than the manufacturer's IEEE tolerance.

Final acceptance depends upon the satisfactory performance of the PFC equipment under test. Do not energize capacitor equipment until the recorded test data has been approved by the Contracting Officer. Submit acceptance test report to the Contracting Officer containing the results of all acceptance tests.

3.2.2 Operation and Maintenance

Provide operation and maintenance manuals with each assembly and include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

-- End of Section --