Automatic, Medium-Voltage, Pad-Mounted, Three-Phase Power Capacitor Bank

Guide Form Specification

1. General

1.1 This specification is for an automatic, medium-voltage, pad-mounted, three-phase power capacitor bank consisting of___________steps of___________kVAR at___________kV RMS and ___________Hertz.

1.2 The power capacitor bank shall be automatically switched based on one of the following parameters or systems: active power (P), current (I), displacement power factor (dPF), reactive power (Q), SCADA, temperature (Θ), time (t) or voltage (V).

1.3 All of the power capacitor bank components are to be housed in a compartmentalized steel enclosure. The power capacitor bank shall come fully assembled and ready for use. All exceptions to this specification shall be clearly stated in your bid. If no exceptions are taken, the bid should include the phrase **No Exceptions Have Been Taken!**

1.4 The electrical ratings for the power capacitor bank shall be compatible with the following power system ratings:

Basic Lightning Impulse Insulation Level (BIL) ____________kV crest

Maximum System Voltage ____________kV RMS

Nominal System Voltage ____________kV RMS

Symmetrical Short Circuit Current Available at the Harmonic Filter Bank

Line-to-Ground ____________kA RMS

Three-Phase ____________kA RMS

2. Codes and Standards

The power capacitor bank shall meet or exceed the applicable requirements of the latest editions of the following codes and standards.

- ANSI Standard C57.12.28-1988, Pad Mounted Equipment Enclosure Integrity
- ANSI Standard Z535.4-01 July 2002, Product Safety Label Standard
- Applicable portions of ANSI Standard C57.21-1990 IEEE Standard Requirements, Terminology and Test Code for Shunt Reactors Rated Over 500 kVA
- Applicable portions of Article 710 in the National Electrical Code
- Article 460 of the National Electrical Code
- CP-1 NEMA Standard on Shunt Capacitors
- IEEE Standard 1036-1992, IEEE Guide for Application of Shunt Power Capacitors
- NESC Standards
- UL-347, High Voltage Industrial Control Equipment
- UL-508, Industrial Control Panels, Issue Number 2, October 1993
- UL-50, Standard for Enclosures for Electrical Equipment

3. Enclosure Construction

3.1 The assembler of the power capacitor bank must also be the manufacturer of the enclosure. This will ensure the highest degree of control with respect to critical enclosure manufacturing processes such as cleaning, painting, priming, surface preparation and welding,

3.2 The power capacitor bank shall be a single compartmentalized unit meeting the requirements of NEMA type____________. All components shall be accessible and removable from the front or rear of the enclosure. The front of the enclosure shall have a dead-front compartment and a control system compartment. The rear of the enclosure shall be a live-front design. Equipment layout and access shall be as follows:

- **Control System Compartment**
  This compartment contains the control system components and the equipment nameplate. The compartment shall be accessible from the front without having to open the dead-front compartment. The compartment shall be completely isolated from the dead-front and live-front compartments. The compartment shall be equipped with a floor.

- **Dead-Front Compartment**
  This compartment shall be equipped with a hinged window that allows for inspection of the blown fuse indicators and when opened, provides access to the fuses. The window shall be fabricated from an impact resistant, ultraviolet resistant material. This compartment shall not be equipped with a floor.

Loop Design:	Contains a full-width, tin-plated copper ground bus; six (6) bushing wells and six (6) stainless steel parking stands.
Radial Design:	Contains a full-width, tin-plated copper ground bus; three (3) bushing wells and three (3) stainless steel parking stands.

- **Live-Front Compartment**
  This compartment contains a full-width, tin-plated copper ground bus, arresters, control power transformer, power capacitor units, stage fuses, stage switches and transient inrush reactors. These components shall be removable from this compartment. This compartment shall be equipped with a floor.

3.3 The enclosure shall be fabricated from twelve (12) gauge, hot-rolled steel, pickled and oiled, ASTM A569 Type 1010. The roof shall be cross-kinked or gabled to allow for watershed.

3.4 The doors shall be flush and removable in the open position. They shall be equipped with stainless steel hinges, stainless steel hinge pins, stainless steel penta-head bolts, stainless steel penta-head threaded inserts and three-point latching handles. The handles shall be pad lockable. All doors shall be equipped with door stays to hold doors in the open position.

3.5 The dead-front and live-front compartment doors shall be fastened with a device that requires a penta-head tool to permit unlatching the door only after the padlock has been removed. The penta-head bolt shall be coordinated such that the padlock may not be inserted into the hasp until the door is fully latched and the penta-head device is secured. A minimum of one (1) penta-head bolt and padlocking means shall be provided for each of the front-compartment and rear-compartment doors. The penta-head bolt shall be surrounded by a non-rotating guard or shall be recessed such that the penta-head bolt can be engaged only with the proper tools. The dimensions of the penta-head bolt and non-rotating recess shall comply with ANSI Standard C57.12.28. The penta-head bolt shall not be readily removable during normal operation of the doors and if removed or disengaged there shall be no holes remaining that would permit entry of a wire into the enclosure. Bi-folding doors may be fastened with a single padlock and penta-head bolt. Access, however, shall be such that a positive and separate action must be taken to open the second door only after the first access door has been opened.

3.6 Removable steel lifting plates shall be located at each corner of the enclosure base.

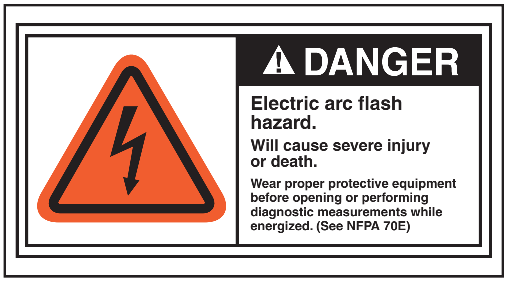
3.7 Ventilation louvers shall be located on the sides of the enclosure and shall be backed with a screen. Air filters shall have washable, aluminum mesh elements and they shall be serviceable from outside of the enclosure.

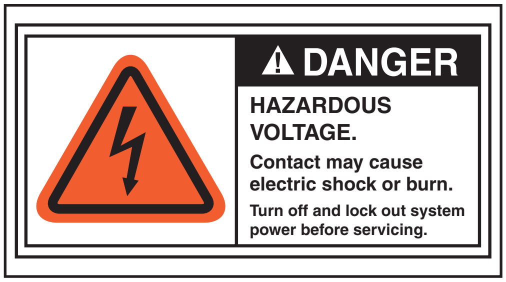
3.8 All fasteners and associated hardware shall be stainless steel. Externally accessible hardware that is used to support electrical components or switch-operating mechanisms that are housed in the enclosure shall be tamper-proof.

3.9 All non-ventilated compartments shall be equipped with strip heaters. The strip heaters shall be controlled with a thermostat.

3.10 If required, a fan or ventilator shall be supplied. The fan or ventilator shall be controlled with a thermostat.

3.11 Each door of the enclosure shall be equipped with self-adhesive vinyl warning signs that comply with ANSI Z535.4 Product Safety Label Standard dated July 1, 2002. The incoming compartment sign shall include signs that state the following information:





3.12 The power capacitor bank shall have a corrosion-resistant nameplate that contains the following information:

- Basic Lightning Impulse Insulation Level (BIL)
- Bank Configuration
- Effective Capacitive Reactive Power per Step
- Effective Capacitive Reactive Power Total
- Hazardous Flash Boundary
- PPE Requirements and Incident Energy (calories per cm^2) at eighteen (18) inches
- Maximum System Voltage
- Nominal System Voltage
- Number of Stages
- Number of Steps
- System Frequency
- Switching Sequence

The nameplate shall be secured to the enclosure with rivets or screws.

3.13 The enclosure shall be prepared and painted with a polyester powder coating using the procedure specified below. The paint color shall be either ANSI 61 or Munsell Number 8.3G 6.10/0.54 (gray), ANSI 70 or Munsell Number 5BG 7.0/0.4 (gray) or Munsell Number 7GY 3.29/1.5 (green).

- **Surface Preparation**
  The following five-stage washer and pre-treatment procedure shall be used.

Stage One:	A heated heavy-duty alkaline cleaner shall be applied to the substrate to remove dirt, oils and other contaminates.
Stage Two:	An ambient temperature city water rinse shall be used to remove any alkali that is remaining on the substrate after stage one. The rinse shall be continuously monitored for water quality. Additional overflow water shall be automatically added if the conductivity exceeds a specified value.
Stage Three:	This surface shall be converted to an iron phosphate coating. The iron phosphate coating improves paint adhesion and also increases the corrosion resistance of the substrate.
Stage Four:	An ambient temperature city water rinse shall be used to stop the iron phosphate conversion process and remove excess iron phosphate from the surface of the substrate. The final rinse in this stage shall apply fresh city water to the substrate before it enters the final stage.
Stage Five:	This stage shall apply a polymeric coating, which seals the iron phosphate coating and provides additional corrosion protection.

- **Paint Coating**

Primer: A zinc rich epoxy coating shall be applied to maximize corrosion resistance. The minimum thickness of this coating shall be 2 mils.

Top Coat: A polyester triglycidal isocyanurate (TGIC) topcoat shall be applied. The minimum thickness of this coating shall also be 2 mils. Weathering of the polyester TGIC is comparable to polyurethane. However, the TGIC coating provides superior edge coverage and maintains excellent mechanical properties with respect to film thickness. The result is excellent performance with respect to both mechanical stability and weathering.

3.14 The manufacturer shall supply written documentation that the applied coating meets or exceeds the tests specified in ANSI Standard C57.12.28-1988.

4. Stage Fuses

4.1 Each power capacitor stage shall be equipped with current-limiting fuses. The stage fuses shall have a short circuit current interrupting capacity that meets or exceeds the available short circuit current at the point where the power capacitor bank is connected to the electrical system.

4.2 The stage fuses shall be equipped with blown fuse indicators. The blown fuse indicators shall be visible through a hinged window located in the dead front compartment. The window shall be fabricated from an impact resistant, ultra violet resistant material. The window shall allow for hot-stick replacement of the fuses after the power connectors have been disconnected and placed on the parking stands.

5. Arresters

5.1 The power capacitor bank shall be shall be equipped with heavy-duty distribution arresters. The maximum continuous operating voltage capability (MCOV) of the arrester shall be specified by the power capacitor bank manufacturer.

6. Transient Inrush Reactors, Optional

6.1 Each power capacitor stage shall be equipped with air-core, single-phase, transient inrush reactors. The transient inrush reactor shall limit the rate-of-rise of the power capacitor stage inrush current (di/dt) to 3.6×10^7 amperes per second. Calculations shall be provided to confirm the manufacturer claims.

6.2 The transient inrush reactor shall have a minimum continuous current rating of 135% of the nominal current rating for the power capacitor stage. When expansion capability is offered, the minimum continuous current rating for the transient inrush reactor shall be 135% of the nominal current rating for the maximum capacity of the stage.

6.3 The manufacturer of the power capacitor bank shall certify that the maximum average winding temperature rise in an ambient temperature of 46°C does not exceed the limiting temperature for the insulation system used in the transient inrush reactor. The certification shall be obtained from heat run data for the transient inrush reactor. The heat run shall be witnessed by a nationally recognized testing laboratory (NRTL).

6.4 The manufacturer of the power capacitor bank shall certify that the basic lightning impulse insulation level (BIL) for the transient inrush reactor is consistent with the basic lightning impulse insulation level (BIL) for the power capacitor bank. The certification shall be obtained from impulse tests made on the actual transient inrush reactor or from impulse tests on a transient inrush reactor of similar construction.

7. Stage Switch

7.1 The power capacitor bank stages shall be controlled by either three (3) single-phase vacuum switches or one (1) three-phase vacuum switch that has been designed and tested for power capacitor switching. The stage switch shall be tested in accordance with ANSI Standard C37.66.

7.2 The stage switch shall be equipped with either motor-driven or solenoid-driven operators.

7.3 The stage switch shall be controlled by an AUTO/OFF/ON selector switch. In the AUTO position, the vacuum switches will be controlled by a suitable controller. In the OFF or ON position, the stage switch will be either OFF or ON, regardless of the controller output signal.

7.4 The control system shall prevent the vacuum switches from operating more than once in a five (5) minute period.

8. Power Capacitor Units

8.1 The bank shall be equipped with all-film, low-loss power capacitor units manufactured by Asea Brown Boveri, Cooper Power Systems or General Electric Company. Depending on the system requirements, power capacitor units can be one-bushing single-phase, two-bushing single-phase or three-bushing three-phase units. The power capacitor units shall be designed, manufactured and tested to meet or exceed all applicable ANSI/IEEE and NEMA standards.

8.2 Each power capacitor unit shall be equipped with internal discharge resistors that will reduce the residual voltage to fifty (50) volts or less five (5) minutes after the power is removed from the unit.

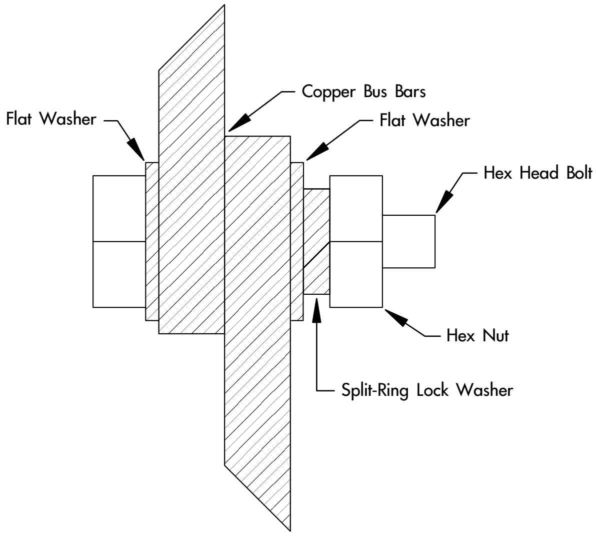
8.3 When the bank has more than one (1) power capacitor unit connected in parallel per phase in a single ungrounded wye configuration then the power capacitor units shall be protected from sustained over-voltages due to a power capacitor unit failure and/or system ground faults by a neutral unbalance detection system.

8.4 The power capacitor units shall be mounted horizontally.

9. Ground and Power Bus

9.1 The ground and power bus shall be silver-plated, round-edge, electrolytic-tough-pitch (ETP) copper, alloy CDA110, hard temper as specified in ASTM B-152 and ASTM B-187.

9.2 The current density in the power bus shall not exceed one thousand (1,000) amperes RMS per square inch. Where expansion capability is required, the power bus shall be rated for the maximum capacity of the power capacitor bank.



9.3 Bolted copper-to-copper connections shall be made with stainless steel hardware. The bolted connections shall be made as shown in the figure above.

9.4 The bus shall be braced to withstand the forces that can be developed by the available short-circuit current at the point where the power capacitor bank is connected to the electrical system.

10. Control System

10.1 The low-voltage control system, where practical, shall be isolated from the medium-voltage compartments. The low-voltage control system, where practical, shall be accessible while the power capacitor bank is energized. The control system shall be listed under UL 508A for Industrial Control Panels.

10.2 The control compartment shall be an integral part of the enclosure; no externally mounted control compartments shall be allowed. The control compartment shall allow for bottom entry of customer control wires without having to enter the medium-voltage compartment. The control compartment shall be equipped with a swing out panel to allow access to the low-voltage control components. The panel shall be equipped with stainless steel hinges and stainless steel hinge pins.

10.3 All low-voltage control wiring that connects to components inside a medium-voltage compartment shall be enclosed in metal conduit or wire troughs that are an integral part of the power capacitor bank enclosure.

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10.4 The power capacitor bank shall be equipped with a suitable controller that will automatically switch **equal** or **unequal** power capacitor bank stages to regulate a customer specified power parameter; i.e., power factor, reactive power, voltage, etc. The controller shall monitor stages for loss of capacitive reactive power output and shall continue to regulate in the event there is a defective power capacitor stage. The controller shall have the following features:

- automatic adjustment to any value of capacitive reactive output produced by the power capacitor stages
- automatic elimination and indication of defective power capacitor stages
- digital indication of set-point, preset parameters and specified installation data
- digital setting of parameters
- harmonic current and harmonic voltage alarms
- RS 232 or RS 485 communications port

10.5 The power capacitor bank shall be equipped with a maintenance interval timer that can be set to alert plant personnel of a maintenance requirement.

10.6 The power capacitor bank shall be equipped with a control power transformer. The primary winding of the control power transformer shall be connected between phase B and phase C. The primary winding of the control power transformer shall be equipped with two (2) current-limiting fuses. The secondary winding of the control power transformer shall be equipped with a circuit breaker.

10.7 Each stage shall be equipped with an AUTO/OFF/ON switch, STAGE ON indicator (green lens) and STAGE OFF indicator (red lens). A delay-on-operate time of five (5) minutes shall be provided for each stage. The manufacturer of the power capacitor bank shall confirm that when switching from the ON position to the AUTO position on any stage, that the corresponding stage will not be energized in less than five (5) minutes.

10.8 A GFI convenience outlet rated for 15 amperes RMS shall be provided in the control compartment.

11. Quality System

11.1 The manufacturer shall be ISO-9001 certified.

11.2 The manufacturer's quality system shall meet all applicable industry standards.

11.3 The manufacturer shall have on staff a professional engineer with a Bachelors of Science in Electrical Engineering and a minimum of ten (10) years experience in medium-voltage power systems.

12. Submittals

12.1 The manufacturer of the power capacitor bank shall provide:

- bill of materials
- component data sheets
- control circuit schematic
- installation instructions
- internal layout drawings
- maintenance instructions
- material safety data sheets (MSDS) for all of the dielectric fluids used in the power capacitor bank
- outline drawings
- pad drawing
- power circuit schematic
- protective relay settings when required
- short circuit coordination study

13. Bid Requirements

13.1 The manufacturer of the power capacitor bank shall state all exceptions taken to this specification in its bid. If no exceptions are taken, the manufacturer must state that no exceptions have been taken.

13.2 The equipment is to be shipped free on board from the factory.

14. Manufacturer's Requirements

14.1 The manufacturer must offer a minimum warranty period of twelve (12) months from first use or eighteen (18) months from date of shipment.

14.2 The manufacturer must show that they are a regular supplier of automatic, medium-voltage, pad-mounted, three-phase power capacitor banks. Product literature and a list of customers that have purchased similar products shall be supplied upon request.

14.3 The manufacturer shall provide a performance guarantee with respect to harmonic resonance and power factor.

14.4 The manufacturer shall be responsible for control cable and power cable coordination.

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