

Power Capacitors

Functional Specification Guide

Pole Mounted Capacitor Rack using Zero Voltage Closing Control

PS230004EN

1. Scope and Function

- a) Pole mounted capacitor racks shall be installed on a distribution feed as an economical means of applying capacitor units to the system. The capacitors' function is to improve the voltage profile of the feeder while improving the power factor of the system and allow Zero Voltage Closing (ZVC) capability.

2. System Information

- a) The pole mounted capacitor racks will be connected on the electrical system having the following characteristics:
 - i) System voltage rating (kV line to line) _____
 - ii) System connection (3 wire wye, 4 wire wye, delta, etc.) _____
 - iii) Available fault current (amperes) _____

3. Capacitor Unit

- a) Capacitor unit tank shall be made using grade 409 stainless steel.
- b) The tank shall be prepared for surface coating and primed with an epoxy primer having a nominal thickness of one mil. The capacitor unit tank shall be spray painted of an urethane finish paint having a nominal thickness of one mil. The color of the finish coat shall be Munsell Color Code 5BG7.0/0.4 light gray. The coating system shall meet the requirements of ANSI C57.12.31 - Pole Mounted Equipment Standard and ANSI C57.12.29 - Coastal Pole Mounted Equipment Standard. Test reports demonstrating compliance with these standards shall be provided with bid. The capacitor unit shall be provided with stainless steel mounting brackets with industry standard 15.62 inch mounting centers.
- c) The underside of each bracket shall not be painted to assure positive grounding.
- d) Each capacitor unit shall have a stainless steel nameplate containing data required by applicable standards.
- e) The capacitor unit shall be supplied with a blue non-PCB decal on the capacitor tank to provide quick and easy identification.
- f) Capacitor unit bushings shall be light gray, wet process porcelain. They shall be glazed for high strength and durability, and shall be hermetically, solder sealed to the capacitor tank. Capacitor units shall be supplied with two bushings except capacitors which have one terminal common to the case shall be supplied with one bushing. The detailed specification shall indicate the number of bushings required.
- g) Each terminal shall be supplied with parallel-groove terminals that accommodate copper or aluminum conductors from No. 8 solid to No. 1 stranded.
- h) The ratings of the capacitor bushings shall have the following characteristics:
 - i) For 95 kv-bil capacitors, the bushings shall have a minimum creepage distance of 10.38 inches, and a minimum strike distance of 6.25 inches.
 - ii) For 125 and 150 kv-bil capacitors, the bushings shall have a minimum creepage distance of 18.12 inches, and a minimum strike distance of 9.50 inches
- i) The capacitor units shall have, at a minimum, shall meet the following:
 - i) Definite (non-probability) capacitor unit tank rupture curve.
 - ii) 10,000 amp fault current handling capability.

- iii) Internal pack construction shall be extended foil, mechanically crimped.
- iv) Constructed of polypropylene film and laser cut foil for maximum DIV performance. Paper film type dielectric capacitors will not be considered. The DIV ratio to operating stress will not be less than 180% at room temperature.
- v) Non-pcb dielectric fluid.
- vi) Capacitor units shall have an internal discharge resistor to reduce the residual charge to 50 volts or less within 5 minutes.
- vii) Capable of being operated in ambient temperatures from -40 to +46 degrees C.
- viii) Capable of being energized at -40 degrees C internal capacitor temperature.
- ix) Compliant to ANSI/IEEE Std, 18 latest revisions.

4. Capacitor Rack Mounting Frame

- a) A pole mounted capacitor rack frame shall be provided to mount the capacitor units. The rack frame shall be made using lightweight, all-aluminum (ASTM 6061-T6). The capacitor rack frame shall include the following features:
 - i) Pole mounting plate with 18 inch mounting hole spacing for direct pole mounting. The pole mounting bracket shall be supplied with a grounding connector and with jump-proof lips. The pole mounting plate shall allow for mounting of the pole mounted capacitor rack to either round wooden or square concrete poles.
 - ii) Legs which allow the capacitor rack frame (with all accessories installed) to sit level on the ground.
 - iii) Four lifting eyes which provide for level lifting.
 - iv) When accessory equipment is required (such as control power transformers, surge arresters, etc), then appropriate mounting brackets shall be supplied for mounting these devices.
- b) The pole mounted capacitor rack shall be supplied with:
 - i) No. 4 solid copper wire for wiring the capacitor units and all accessory equipment.
 - ii) Opti-G birdguards for capacitor units and switches when required.
 - iii) Birdguard protection (tubing) between capacitor units.
 - iv) Stainless steel hardware for mounting capacitor units and required accessories.
 - v) Factory assembly of capacitor units and required accessories. If any component of the capacitor rack is to be shipped separately, then the quotation shall so indicate.
- c) The capacitor rack shall have proper electrical clearances for the voltage rating specified in the detail specification.
 - i) For 95 kv-bil applications, ____ phase to ground and ____ phase to phase electrical clearances shall be maintained.
 - ii) For 125 and 150 kv-bil applications, ____ phase to ground and ____ phase to phase electrical clearances shall be maintained
- d) Each pole mounted capacitor rack assemble shall be factory shipped on an appropriate wooden pallet or skid.
- e) The capacitor rack frame shall be an "in-line" type. It shall be sized to accommodate three, six, or nine capacitor units as required by the detailed specification. Six and nine unit frames shall be provided with sway braces. The rack frame shall be capable of mounting manufacturers ANSI and NEMA standard capacitor units without requiring multiple rack sizes for different size kvar units.

5. Capacitor Rack Switching for Zero Voltage Closing

- a) In addition to the requirements mentioned previously, switched pole mounted capacitor racks shall be supplied with switches and junction box.

- i) Vacuum Capacitor Switches shall be used to switch the pole mounted capacitor rack. The switches shall be manufactured and tested in accordance with the latest revision of IEEE Std. C37.66-2005. Switches shall be rated as follows:
- | | | | |
|--|------|------|------|
| • Distribution system voltage class (kv) | 15 | 25 | 35 |
| • Rated Impulse Withstand Voltage (kv-bil) | 95 | 125 | 125 |
| • Continuous current rating (amps) | 200 | 200 | 200 |
| • Symmetrical current rating (amps) | 6000 | 6000 | 6000 |
| • Asymmetrical current rating (amps) | 9000 | 9000 | 9000 |
| • High frequency transient (amps) | 9000 | 9000 | 9000 |
| • Transient Inrush Frequency (hz) | 6000 | 6000 | 6000 |
- ii) The capacitor switch control circuit must be configured for dc pulse operation for Zero Voltage Closing (ZVC).
- iii) Each Vacuum switch shall include a 5 or 6 pin receptacle for connection to the junction box. Each switch shall be factory assembled and wired to the pole mounted bank at the factory. One vacuum switch shall be provided per phase. The switch control voltage shall be 120 vac, 60 hz.
- iv) The vacuum switches shall be mounted on the front angle away from the pole, or on the rear angle on the pole side. In the case of a 3 unit rack frame with switches mounted on the rear angle, one of the three switches is to be end mounted on the rack due to physical clearances.
- v) Each switch shall be provided with a manual open operating handle to prevent line crews from accidentally closing the capacitor switch into a faulted bank.
- vi) Switches shall be Eaton's vacuum type Edison Capacitor Switch (ECS).
- vii) The capacitor switch shall have a C2 restrike class in accordance with the latest revision of IEEE C37.66.
- b) Switch Features
- i) The switch shall be maintenance free. No routine maintenance is required.
- ii) The switch shall be operable in any mounting orientation.
- iii) The switch shall withstand a minimum of 50,000 mechanical operations (one operation equals one open operation plus one close operation).
- iv) 15 kV switch can be designed up to 610 mm terminal to ground creepage. The 25 kV & 35kV can be a designed up to 813 mm terminal to ground creepage.
- v) Load side termination ring designed for 360 degree terminations (no need to break seals to rotate head for directional connections). Design also allows for termination of multiple loads.
- vi) Bushing constructed of low viscosity cycloaliphatic epoxy resin. Designed to IEC 60815 SPS class E.
- vii) Permanent Magnetic Solenoid design for robust mechanical operation (no cams, linkages, struts, or pins). No relays or switching electronics allowed in the body of the switch.
- viii) Optional accessories include bird guards for all terminals, auxiliary contacts, and additional load terminals
- ix) Mounting bracket made from type 304 stainless steel.
- c) Each switched pole mounted capacitor bank shall be supplied with a polymer or painted steel, weather-resistant junction box to terminate low voltage switch wiring. The junction box shall include control cables with a 5 or 6 pin plug to connect to the vacuum switches. The junction box shall be mounted on the side of the rack near the rack pole mounting bracket.
- i) The junction box shall be supplied with a 6 point terminal strip with the following designation:
- | | |
|-----------|-----|
| a) Line | "L" |
| b) Common | "G" |
| c) Close | "2" |

- d) Trip "3"
- ii) The wire from the junction box to the switches shall be 3 conductor #16 cable (additional conductors may be required for any required switch accessories). The cable shall have the following color code:
 - a) Common White
 - b) Close Red
 - c) Trip Black
- iii) The wire from the junction box to the CPT (when required) shall be 2 conductor #12 cable, and shall have the following color code:
 - a) Line _____
 - b) Common _____
- iv) The control cable from the junction box to the oil switch shall be terminated with a 5 pin, screw on plug which shall have the following pin designations:
 - a) Pin A Not Used (May be used for switch accessories)
 - b) Pin B Ground
 - c) Pin C Close
 - d) Pin D Trip
 - e) Pin E Not Used (May be used for switch accessories)
- v) The junction box shall be supplied with plug receptacles such that cables from switches and the transformer can be plugged into the junction box. Cable entry entrance bushings facilitating hardwire connections shall not be permitted.
- vi) The junction box shall be supplied with a captive screw and chain on the cover.

6. Zero Voltage Control (ZVC)

- a) ZVC control must be able to run calibration procedure in 1 minute or less per phase.
- b) ZVC control must maintain 0.4ms accuracy during closing operation for the entire operating temperature range.
- c) ZVC must be capable of indicating open status of all three vacuum capacitor switches with only Neutral (B), Close (C) and Trip (D) wire connected.
- d) Open status of ZVC capacitor control means all three switches are in the open position.
- e) Closed status of ZVC capacitor control means all three switches are in the closed position.
- f) Status of Open or Close condition of capacitor switches must be shown on the front panel.
- g) Status must be provided through a set of dry contacts, RS-232 or fiber optic outputs.
- h) ZVC control must be capable of remote operation using RS-232 or fiber optic connections.
- i) ZVC control must be capable of working with the Edison Capacitor Switch.
- j) ZVC control must be capable of operating accurately for frequency ranges 47 to 63Hz.
- k) ZVC control must be capable of learning and adjusting to capacitor switch wear and break-in variations.

7. Accessories

- a) Control power transformer
 - i) A control power transformer (CPT) shall be supplied to operate the capacitor switches, capacitor control and Zero Voltage Control. The CPT shall be 1.0 kva minimum. The secondary shall be rated 120 vac.

- a) For three phase, four wire systems, the CPT shall be connected line to neutral. The CPT shall be supplied with one high voltage bushing, and one low voltage bushing terminal. Grounding of the CPT shall be accomplished by a high voltage grounding lug on the transformer tank, and a low voltage grounding lug on the transformer tank.
- b) For three wire (no neutral) systems, the CPT shall be connected line to line. The CPT shall be supplied with 2 high voltage bushings, and one low voltage bushing. Grounding of the CPT shall be accomplished by a high voltage grounding lug on the transformer tank, and a low voltage grounding lug on the transformer tank.
- ii) The CPT shall have the following features:
 - Wild life protector(s) on the high voltage terminal(s)
 - An internal weak link fuse
 - Pressure safety valve
 - Non-PCB label
 - Standard NEMA pole mounting bracket
 - Stainless steel hardware
 - Finish coat of paint shall be sky gray (1 primer, 2 finish coats)
 - Kv-BIL rating consistent with the application
 - Bushing creepages shall be consistent with the application
- iii) The CPT shall be mounted on the pole mounting rack prior to shipment from the factory. All necessary high voltage (including wildlife protection) shall be provided. A cable shall be supplied from the junction box to the CPT.
- b) Surge arresters
 - i) When required by the detail specification, the pole mounted capacitor rack shall include one distribution class type MOV surge per phase. The surge arrester shall be mounted and wired on the pole mounted capacitor rack.
 - ii) The surge arrester shall be Eaton's type UHS or URS (polymer), or equal.
 - iii) The rating of the surge arrester shall be supplied as stated on the detailed specification, or at the discretion of the supplier.
- c) Other accessories

8. Other accessories such as fuse cutouts, controls, etc will be specified separately.

9. Detailed Specification

Item	1	2	3	4
Three Phase Pole Mounted Rack Kvar				
Line to Line System Voltage Rating (kv)				
Bank Connection (Ungrounded wye, grounded wye, delta)				
Kvar Size of Capacitor				
Voltage Rating of Capacitor				
Number of Capacitor Bushings (1 or 2)				
Kv-Bil Rating of Capacitor				
Rack size (3, 6, or 9)				
Switch Options (fixed, switched)				
Capacitor Control (yes, no)				
Zero Voltage Closing Capacitor Control (yes, no)				
Control Power Transformer (yes, no)				
Surge Arresters (no, yes - kv rating /porcelain, yes - kv rating/polymer)				
Control power transformer (no, yes)				

Notes: _____
