

# STANDARD SPECIFICATION FOR PAD-MOUNTED CAPACITOR BANKS FOR 15kV or 25kV APPLICATIONS

Note - This is a specification guideline. Other designs will be considered. Please consult factory.

## A. General

### 1. Product

The pad-mounted capacitor banks shall be in accordance with the applicable plans, drawings, and one-line diagrams and shall conform to these specifications.

### 2. Assembly

The outdoor pad-mounted capacitor banks shall consist of a single self-supporting enclosure, with capacitors, cable-termination points, capacitor fuses, capacitor switches, inductive reactors (optional), fused voltage transformer (optional), and control components as specified by the customer. The unit will be factory assembled and tested.

### 3. Configurations (radial or loop feed)

- a) Outdoor pad-mounted primary capacitor banks shall be specified by the customer for its intended applications, radial feed or loop feed.
- b) "Radial" designs shall have three (3) bushing wells (for 200-ampere applications) or three (3) bushings (for 600-ampere applications) on the incoming and outgoing points for cable connection.  
Specify 200-ampere bushing wells or 600-ampere bushings.
- c) "Loop" (or "feed-through") designs shall have six (6) bushing wells (for 200-ampere applications) or six (6) bushings (for 600-ampere applications) on the incoming and outgoing points for cable connection.  
Specify 200-ampere bushing wells-or 600-ampere bushings.

### 4. Ratings

The ratings for the integrated pad-mounted, medium-voltage three -phase capacitor banks shall be as follows:

System Voltage, BIL, Load Current Rating, Frequency, Fault Current Rating		
	15kV	25kV
kV, Nominal	15	25
kV, Maximum Design	15.5	27
kV, BIL	95	125
Main Bus Continuous, Amps	200A or 600A	
System Frequency (specify if 50 Hz)	60Hz (50 Hz available)	
Available Three-Phase Fault Current (kA, RMS sym.)	Specify	
Available Phase-to-Ground Fault Current (kA, RMS, sym.)	Specify	

### kVAR Rating of the Capacitor Bank

The total kVAR for the capacitor bank shall be specified. Since this is typically a three-phase application and the most common single-phase capacitor unit sizes are 50 kVAR, 100 kVAR, 200, kVAR 400 kVAR, 500 kVAR, and 600 kVAR the most commonly specified total capacitor bank sizes are:

150 kVAR	900 kVAR	1800 kVAR
300 kVAR	1200 kVAR	2400 kVAR
600 kVAR	1500 kVAR	3600 kVAR

(Note: Additional capacitor bank sizes can be furnished based on other combinations of the available capacitor sizes.)

Unless otherwise specified, capacitor banks will be assumed to be of the one-step design (on or off). Consult factory for multi-step/staged capacitor banks.

### 5. Certification of Ratings:

The capacitor bank manufacturer shall be completely and solely responsible for the performance of the basic components as well as the complete integrated assembly as rated, with the exception of when any current and/or voltage sensing transformers are specified by, supplied by, or later installed by the customer or a third party.

The manufacturer shall furnish, upon request, certification of ratings of the basic capacitor bank components and/or verification of the capability of the integrated switchgear assembly consisting of the switchgear assembly, primary bus, and cable connection points.

### 6. Compliance with Standards and Codes

The pad-mounted capacitor bank shall conform to or exceed the applicable requirements of the following standards and codes:

- a) All portions of ANSI C57.12.28 covering enclosure integrity for pad-mounted equipment.
- b) Applicable portions of IEEE standards covering the design and testing of the basic enclosure, capacitors, components, and ways.
- c) Applicable portions of IEEE-386 – IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems above 600 V.

### 7. Enclosure Design

The enclosure of the pad-mounted capacitor bank shall be provided with the following considerations:

- a) To ensure a completely coordinated design, the pad-mounted capacitor bank shall be constructed in accordance with the minimum construction specifications required to provide adequate electrical clearances and adequate space for operation of the unit and any required handling of components.

**Specifications must be verified by factory.**

- b) In establishing the requirements for the enclosure design, consideration shall be given to all relevant human factors, such as controlled access and tamper resistance, as well as environmental factors, such as ingress of air-borne contamination and any ventilation which may be necessary for control of moisture and condensation.
- c) A drip pan shall be provided under the capacitors to collect any liquid that may result from leakage or rupture of the capacitor.

Optional Features - Specify as Required

- d) The area under the components, except termination sections where cables enter the unit shall be furnished with a galvanized steel floor angled to permit moisture to flow to the corners, which shall include stainless steel screens. This floor will be under drip pans called for in section C.

## B. Construction – Assembly

### 1. Insulators, Bushings, and Bushing Wells

The pad-mounted capacitor bank insulators, bushings, and bushing wells shall have the following material characteristics and restrictions:

- a) Operating experience of at least twenty (20) years under similar conditions.
- b) Ablative action to ensure non-tracking properties.
- c) Adequate leakage distance established by test per IEC Standard 60507.
- d) Adequate strength for short-circuit stress established by test.
- e) Conformance to applicable ANSI and IEEE standards.
- f) Homogeneity of the cycloaliphatic epoxy resin throughout each insulator, bushing, and bushing well to provide maximum resistance to power arcs. Ablation due to high temperature from power arcs shall continuously expose more material of the same composition and properties so that no change in mechanical or electrical characteristics takes place because of arc-induced ablation. Furthermore, any surface damage to insulating components during installation or maintenance of the pad-mounted gear shall expose material of the same composition and properties so that insulating components with minor surface damage or imperfections need not be replaced.
- g) Each insulator, bushing, and bushing well shall be x-rayed to assure it is essentially void-free. An alternative testing method may be used only by approval of the engineer.
- h) Conductor rods of bushings and bushing wells shall be of all copper, with the associated studs to be copper with a silver flash.

### 2. High Voltage Bus and Connections (where used)

- a) Bus and interconnections shall consist of bare aluminum bar of 56% IACS conductivity with an oxide-inhibiting agent at all bus joints.
- b) Bus and interconnections shall withstand the stresses associated with short circuits up through the maximum

rating of the pad-mounted gear, including proper allowance for transient conditions.

- c) Bolted aluminum to aluminum connections shall be made with a suitable number of non-corrosive bolts, with two Belleville spring washers per bolt, one under the bolt head and one under the nut, or with a wide-flange head bolt and one Belleville spring washer under the nut, per bolt. As an alternate, bolted aluminum-to-aluminum connections shall be made with a suitable equivalent surface area, i.e. – 1-bolt and spring washer. Bolts shall be tightened to an appropriate torque to assure good electrical connection.
- d) Before installation of the bus, all electrical contact surfaces shall first be prepared by abrading to remove any aluminum-oxide film. Immediately after this operation, the electrical contact surfaces shall be coated with a uniform coating of an oxide inhibitor and sealant.

### 3. High Voltage Cable Connections (where used)

- a) Bare stranded #2 AWG copper cable is used to connect the ground terminal of the capacitors to the ground bus, where applicable.
- b) Bare stranded #2 AWG copper cable is used to connect reactors to the capacitors, where applicable.

### 4. Ground Connection Pads

- a) A ground connection pad shall be provided in each compartment of the pad-mounted gear.
- b) The ground connection pad shall be constructed of 1/4" thick, stainless steel and have a NEMA 2-hole pattern for ground connections. The pad shall be welded to the enclosure and shall have a short-circuit rating equal to that of the integrated assembly.
- c) A full-width copper ground rod shall be provided on the cable termination compartment side of the enclosure.

### 5. Low-Voltage Components

Low voltage components and associated wiring shall be installed with considerations as follows:

- a) All low-voltage components shall be either mounted externally to the enclosure or shall be otherwise isolated from high-voltage in an approved location and in an appropriate manner inside the unit so as to minimize exposure to high-voltage.
- b) Low-voltage wiring, except for short lengths such as at terminal blocks and the secondaries of sensing devices, shall be shielded where necessary, and to the extent possible, for isolation from high-voltage.

## C. Construction – Enclosure & Finish

### 1. Enclosure and Roof

- a) The capacitor bank enclosure shall be of unitized construction (not structural frame and bolted sheet) to maximize strength, minimize weight, and inhibit internal corrosion.
- b) The basic material for the enclosure, roof, and doors shall be 11-gauge, hot rolled, pickled and oiled steel.
- c) All structural joints and butt joints shall be welded, and the external seams shall be ground flush and smooth. A welding process shall be employed that eliminates alkaline residues and minimizes distortion and spatter.

- d) To guard against unauthorized or inadvertent entry, enclosure construction shall not utilize any externally accessible hardware.
- e) The base shall consist of continuous 90-degree flanges, turned inward and welded at the corners, for bolting to the concrete pad.
- f) The door openings shall have 90-degree flanges, facing outward, that shall provide strength and rigidity as well as deep overlapping between doors and door openings to guard against water entry.
- g) In consideration of tamper resistance, the enclosure shall conform to, or exceed, the requirements of ANSI/IEEE C57.12.28.
- h) A heavy coat of insulating "no-drip" compound shall be applied to the inside surface of the roof to reduce condensation of moisture thereon.
- i) The roof shall be removable, with bolts accessible in the termination compartment and in the capacitor compartment.
- j) Lifting tabs shall be removable. Sockets for the lifting-tab bolts shall be blind-tapped. A protective material shall be placed between the lifting tabs and the enclosure to prevent the tabs from scratching the enclosure finish. This material shall be non-hygroscopic to prevent moisture from being absorbed and held against the enclosure.
- k) To prevent moisture ingress, the roof shall be one-piece construction and shall not include any gasketed joints or any unground welded butt joints exposed to the exterior.
- l) Any welded butt joints exposed to the exterior shall be ground smooth prior to painting.
- m) A steel equipment wall is provided for mounting of the bushing wells and/or bushings, as well as to separate the dead-front cable compartment from the live-front medium-voltage capacitor compartment.

#### The following optional features may be specified

Type 304 stainless-steel external surfaces (doors, roof and enclosure). Stainless-steel to be 11 gauge.

Stainless-steel or non-ferrous hardware, including internal mounting angles, brackets, etc, and with three-point roller latch ("slim-line" latch) on door replacing the automatic door latch system.

All stainless-steel – combines both options above.

## 2. Barrier Assembly

Insulating barriers shall be provided in each compartment as required to achieve necessary insulation levels. This barrier system shall be constructed of fiberglass reinforced polyester (NEMA rated GPO-3).

Such barriers would include, but are not limited to:

- a) Removable GPO3 barriers on the live-front compartment side, hanging/lifting off style, secured to the enclosure with penta-head bolts, shall be provided to further restrict immediate access to medium voltage components when the outer steel compartment doors are open.
- b) Inter-phase and phase-to-ground barriers required for electrical clearances.

- c) A clear polycarbonate barrier shall be provided above the steel equipment wall in the termination compartment to allow viewing of the position indicators on the capacitor switches. The barrier shall also include openings to allow access to, and tripping of, the manual trip handles of the capacitor switches using an appropriate insulating universal pole or "shotgun" type clamp stick.

#### The following barrier options may be specified

Clear polycarbonate barriers instead of red GPO-3 fiberglass.

Hinged barriers instead of lift-off barriers on the live-front, capacitor compartment, side.

For other customer-specific optional barriers, consult the factory.

## 3. Doors

- a) Doors shall be constructed of 11-gauge hot-rolled, pickled and oiled sheet steel.
- b) Door edge flanges shall overlap with door opening flanges and shall be formed to create a mechanical maze that shall guard against water entry and discourage tampering or insertion of foreign objects.
- c) Doors shall have a minimum of three hinges, stainless steel or other inherently non-corrosive material, each with stainless-steel hinge pins. The hinge pins shall be secured in place to guard against tampering.
- d) One active and one passive door shall be provided in each case where there are two adjacent doors. In consideration of controlled access and tamper resistance, each active door shall be equipped with a positive-action three-point auto-latch mechanism and padlock hasp.
- e) Each active door shall be provided with a hinged stainless-steel cover over the door-latch operating bolt. The cover shall be padlockable and shall incorporate a hood to protect the padlock shackle from tampering and access to the door-latch operating bolt.
- f) Each door-latch operating bolt shall be a recessed penta-head bolt (hex-head optional) for security.
- g) Each passive door shall be independently secured (bolted or latched) to the enclosure.
- h) Each door shall be provided with a stainless-steel door holder (or "wind brace") located above the door opening. These holders shall be hidden from view when the door is closed. It shall not be possible for the holders to swing inside the enclosure.

## 4. Finish

- a) Full coverage at joints and blind areas shall be achieved by processing enclosures independently of components, such as doors and roofs, before assembly as unitized structures.
- b) All exterior welded seams shall be sanded or ground smooth for neat appearance.
- c) All surfaces shall undergo a chemical cleaning, phosphatizing or zirconization and sealing process before any protective coatings are applied in order to remove oils and dirt, form a chemically and anodically neutral conversion coating, improve the finish-to-metal bond, and retard under-film propagation of corrosion.
- d) The finishing system shall be applied without sags or runs.

- e) After the enclosure is completely assembled and the components (bus, bushings, etc.) are installed, the finish shall be inspected for scuffs and scratches.
- f) Blemishes shall be carefully touched up by hand to restore the protective integrity of the finish.
- g) Unless otherwise specified, the color shall be Munsell No. 7GY 3.29/1.5, bell green.
- h) To ensure that the finishing system is capable of resisting corrosion, the manufacturer shall provide, on request, certification that the representative test panels, protected by the manufacturer's finish system, have passed the coating system performance requirements in ANSI/IEEE C57.12.28 as verified by an independent third party certifier, such as UL®.

## D. Components

### 1. Cable Termination Compartments

- a) Cable termination compartments shall be provided with 600-ampere rated apparatus bushings and/or 200-ampere bushing wells, as specified by the customer.
  - i. Each 600-ampere rated bushing shall include a removable silver-plated copper threaded stud to accommodate a choice of elbow termination systems.
  - ii. Each 200-ampere rated bushing well shall have a removable silver-plated copper stud and shall be designed to accept 200-ampere bushing inserts.
- b) Bushings and bushing wells shall have interfaces in accordance with ANSI/IEEE Standard 386 to accept all standard separable insulated connectors and inserts.
- c) A stainless-steel parking stand shall be provided adjacent to each bushing and bushing well and shall be spaced to accommodate horizontal feed-through assemblies and stand-off bushings.
- d) A location to accommodate drain wires from elbow connectors shall be provided in each bushing or bushing-well clamping plate or at an adjacent location.

### 2. Live-Front Compartment for Access to Components

- a) An insulated, hanging, GPO-3 barrier system, secured with pentahead bolts, inside the exterior steel doors, shall be provided to restrict access to the medium-voltage capacitor compartment.
- b) Voltage (or "Potential") Transformers
  - i. Unless otherwise specified by the customer, voltage ("potential") transformers shall be installed by the manufacturer.
  - ii. The voltage transformer shall provide control power for operation of the capacitor switches and, if required, provide voltage sensing and control power for the controller.
  - iii. The voltage transformer shall be installed inside the capacitor-bank enclosure on the line side of one phase immediately after the bushing or bushing well.
  - iv. Voltage Transformers shall be isolated from medium voltage by an enclosing barrier system.
- c) Voltage transformers shall be individually fused with appropriate current-limiting (non-expulsion) fuses.
- d) The following options may be provided:

- i. Insulating clear polycarbonate hinged inner barrier with pentahead bolt closures.
- ii. Hex-head bolts may be requested in lieu of pentahead bolts.

### 3. Capacitors

- a) Capacitors utilized in the pad-mounted capacitor banks shall be an all-film design and be in compliance with IEEE Std.18.
- b) Capacitors utilized shall be equipped with an internal discharge device that will reduce the residual voltage to 50V or less within the five minutes after the capacitor is disconnected from the peak of rated voltage.
- c) The following brands of capacitors are considered standard offerings – ITI (GE), ABB, Cooper, and General Electric (now ITI).
- d) The customer may specify any of the listed standard brands in the purchase order documents (A = ABB, C = Cooper, G = ITI/GE). Consult the factory if other brands are required.

### 4. Capacitor Fuses (Current-Limiting Fuses)

- a) Each capacitor or group of capacitors on a phase (or "leg") shall be protected by current-limiting fuses.
- b) Fuse mountings shall be clip style and allow for visibility of the blown-fuse targets.
- c) Fuses shall be visible and accessible behind a clear and removable (or hinged) polycarbonate barrier.
- d) Standard fuse offerings are the Hi-Tech current-limiting fuse ("H"), Cooper X-Limiter current-limiting fuse ("L") and the Cooper NX current-limiting fuse ("N").
- e) Other fuses ("X") may be specified in the customer's purchase order documents.

### 5. Capacitor Switches

- a) Capacitor rated switches shall be provided in each phase ("leg") to switch the capacitive current and when open to isolate the capacitors from the incoming circuit.
- b) Switches used for isolating capacitors shall be rated for capacitor switching duties for loads up to 200-amperes.
- c) Vacuum-type capacitor switches are considered to be standard.
- d) Single-phase solid dielectric 200-ampere vacuum capacitor rated switches are the standard offering. Joslyn and ABB are typical examples.
- e) Other brands of vacuum switches may be specified by the customer.

### 6. Inductive Reactors

- a) Inductive reactors, one per phase, to limit capacitive in-rush currents are normally supplied with capacitor banks. 40 $\mu$ H (micro-Henries) and 60 $\mu$ H are standard values. Contact the factory if other values are required.
- b) If reactors are to be supplied, the customer shall provide the required value in micro-Henries ( $\mu$ H).
- c) The customer may optionally elect to not install reactors.

### 7. Capacitor Bank Controller

- a) Capacitor bank may be ordered with, or without, a controller, or with provisions for a customer supplied controller (mounting ring only).
- b) If the customer orders a factory installed controller and mounting ring, the customer must specify the controller brand and part number.
- c) If the customer orders a mounting ring only, then the customer must specify the controller mounting ring brand and part number. (Controller by others).
- d) Controller rings are mounted on the exterior as a standard.  
Other locations, such as installed inside the equipment or inside an externally mounted enclosure can be specified as an option.

### 8. Other Optional Components and Features

- a) Wiring  
Factory wiring shall be provided, as required, to connect to the customer supplied controller.
- b) Provisions for Antenna  
Provide enclosure and/or control box opening for antenna per customer requirements.
- c) Additional Configurations and Options  
Consult the factory for dimensions, configurations, and other optional features that may be desired.

## E. Labeling

### 1. Warning Signs

All active and passive doors shall be provided with an approved external "Warning – High Voltage – Keep Out" sign.

### 2. Additional Hazard-Alerting Signs and Labels

- a) The inside of each door of the live-front component access compartment shall be provided with a "Danger – High Voltage – Keep Out – Qualified Persons Only" sign.
- b) Each barrier in the live-front component access compartment shall be provided with a "Danger" sign on both sides.
- c) Each barrier providing access to a primary voltage fuse shall be provided with a sign indicating that "Fuses may be energized in any position" on both sides of the barrier.

### 3. Nameplates, Ratings Labels, & Connection Diagrams

- a) The outside of the active door on both the front and back shall be provided with nameplates indicating the manufacturer's name, serial number, catalog number, model number, and date of manufacture.
- b) The inside of each door shall be provided with a ratings label indicating the following: capacitor bank size in kVAR, voltage ratings, main-bus continuous current rating, short-circuit ratings (amperes RMS symmetrical at rated nominal voltage), the type of capacitor fuse and its rating, capacitor switch ratings, and approximate unit weight.
- c) A three-line connection diagram showing the bus, terminations, capacitors, capacitor switches, fuses, reactors (if applicable) and locations of the VTs (or PTs) will be provided on the inside of the each door.

Individual interior labeling shall be provided for the following:

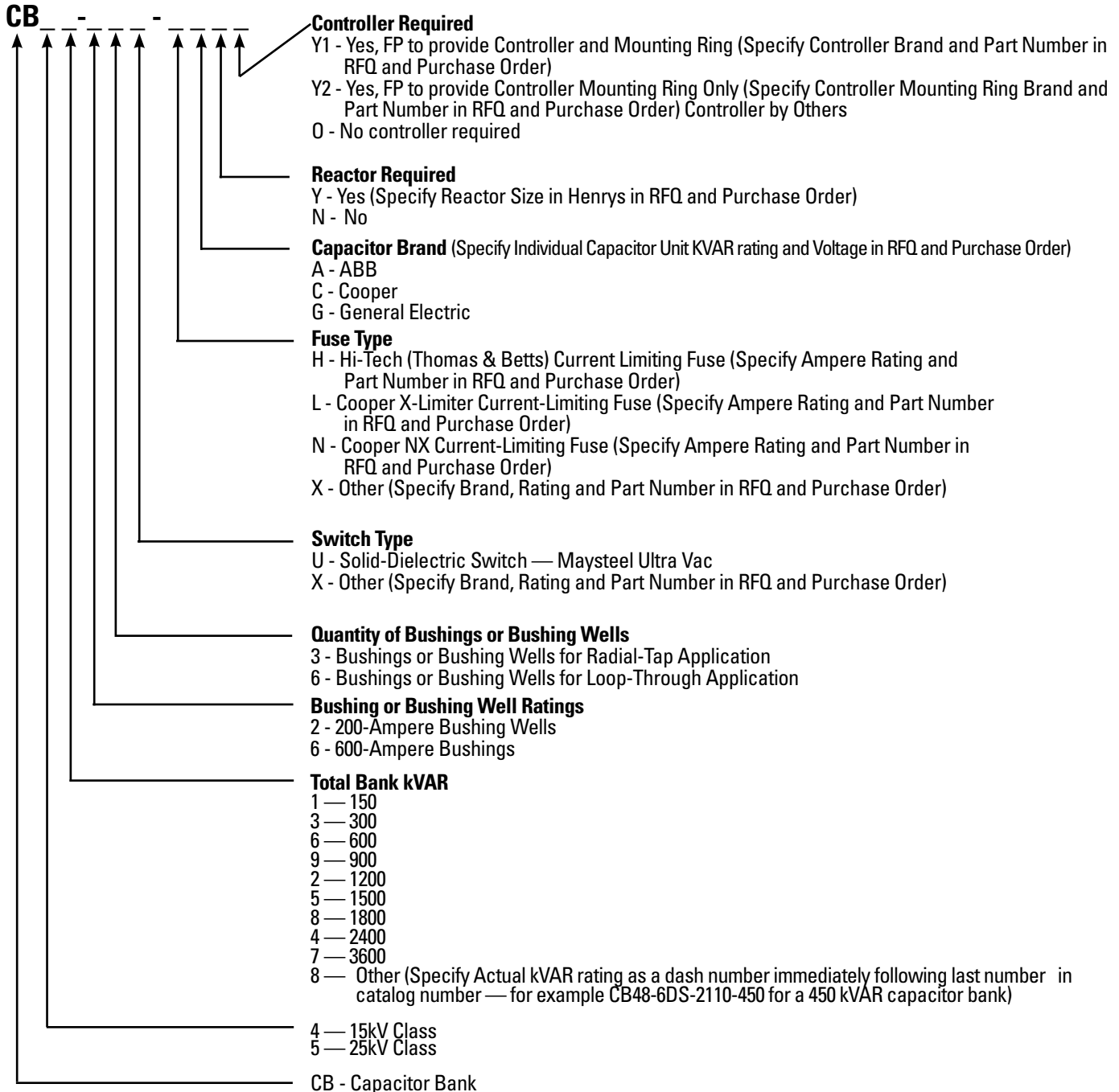
- d) Phase identification (numbered)
- e) Elbow Compartment
- f) "Line" bushing well (or bushing) identification
- g) "Load" bushing well (or bushing) identification
- h) Component Access Compartment

### F. Alternate Designs and Other Optional Features

Consult the factory for alternate designs and other optional features.



## G. Pad-Mounted Capacitor Bank Catalog Number Designations



## H. Standard Options Catalog Number Designations Suffixes

### 1. General Information

- a) The following options may be appended to the base catalog number developed in Section G.
- b) The formatting is to separate each suffix from the base unit, or preceding suffix, with a hyphen.
- c) Suffixes should be added in ascending alpha-numeric order (alpha, then numeric, ascending).

### 2. Barrier options may be specified

**B6** - Clear polycarbonate barriers instead of red GPO-3 fiberglass

**B7** - Hinged barriers instead of lift-off barriers on dead-front side

**B8** - Hinged barriers instead of lift-off barriers on the live-front side.

### 3. Special Finish Color and Materials which may be specified

**C** - All Copper Bus

**F2** - ANSI 61 Light Gray

**F3** - ANSI 70 Sky Gray

**F5** - Coal Tar coating on lower three inches of the cabinet

**F6** - Type 304 stainless-steel external surfaces (doors, roof and enclosure). Stainless steel to be 11 gauge.

**F7** - Stainless-steel or non-ferrous hardware, including internal mounting angles, brackets, etc, and with three-point roller latch ("slim-line) on door replacing the automatic door latch system.

**F8** - All stainless-steel – combines F6 and F7.

### 4. Other options not listed are likely available. Please contact the factory for additional information.

### 5. Sample catalog number, with options:

**CB42-26X-XCYY2-B6**

**CB42** - Capacitor Bank 15kV 1200 kVAR

**26X** - 200A Bushing Wells x 6 (loop through design), "Other" switch

**XCYY2** - Other fuse type, Cooper Capacitors, Reactor, mounting ring only

**B6** - Clear polycarbonate barriers instead of red GPO-3 fiberglass



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**Specifications must be verified by factory.**

Every effort is made to ensure that customers receive up-to-date information on the use of Federal Pacific products; however, from time to time, modifications to our products may without notice make the information contained herein subject to alteration.

