BURLINGTON ELECTRIC DEPARTMENT (BED)
MATERIAL SPECIFICATION

15 kV Class, Switched, Padmount Capacitor Bank

SCOPE

This specification is for a medium voltage three phase above-grade pad-mounted capacitor bank suitable for use on BED's 13.8 kV, 4-wire, 3 phase, grounded wye system. The bank shall be complete with enclosure, capacitors, surge arresters, switches, fuses, control transformer, interconnecting wires and fittings. The capacitor bank shall come fully assembled and ready for installation.

INDUSTRY STANDARDS

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

UL-508	Industrial Control Panels, Issue Number: 2, October 1993
ANSI C57.12.28	Pad Mounted Equipment Enclosure Integrity
IEEE Std. 1036	IEEE Guide for Application of Shunt Power Capacitors
IEEE Std. C37.99	IEEE Guide for the Protection of Shunt Capacitor Banks
IEEE Std. 18	IEEE Standard for Shunt Power Capacitors
ANSI. C37.66	Standard Requirements for Oil-Filled Capacitor Switches for Alternating-Current Systems
IEEE 386	Standard for Separable Connectors
CP-1 NEMA	Standard on Shunt Capacitors
ANSI C2	National Electrical Safety Code, (NESC Standard)
UL-50	Standard for Enclosures for Electrical Equipment

The padmounted capacitor bank shall further meet and/or exceed those applicable standards not stated herein but referenced by the above standards. In cases where this specification conflicts with the industry standards, this specification shall take precedence. Specific exceptions to this specification or to applicable industry standards shall be clearly noted with each quotation.

CAPACITOR BANK CONSTRUCTION

General

The total kVAR rating of the capacitor bank, the number of stages and the kVAR rating of each stage shall be as specified on the RFQ / purchase order.

The ratings of the bank and associated switchgear, switching devices, capacitors, fuses, and all other applicable components shall have ratings designed for application on the following system:

- Nominal System Voltage Line-to-Line…. 13.8 KV
- Maximum Design Voltage……..…….……. 15.0 kV
- Bank Connection……. Grounded Wye
- Line-to-Ground Voltage…….…… 7.96 KV
- System BIL…….……...…… 95 kV
- Three Phase Short Circuit Rating at Capacitor Bank (RMS Symmetrical Amps)……. 16 KA
- Line-Ground Short Circuit Rating at Capacitor Bank (RMS Symmetrical Amps)…….. 16 KA
- Elevation ……..…… <1,000 feet
- Ambient Temperature Range ……. -40ºF to 100ºF

Enclosure

All controls, switching devices, and protection features are enclosed in a single, compartmentalized, all-welded, steel enclosure that meets or exceeds the most recent version of ANSI C57-12.28. The enclosure shall house all components, including fuses, capacitors, capacitor switches, wiring and associated controls. All components shall be accessible and removable from the front or rear of the enclosure. The front side of the enclosure shall have a dead-front compartment and a control compartment. The rear of the enclosure shall be of a live-front design. Equipment layout and access shall be as follows:

- Control Compartment – Contains the capacitor bank controller, ancillary control components, and nameplate. This compartment is accessed from the front (without having to open the live-front or incoming dead-front compartment) and is completely segregated from the live-front and incoming dead-front compartments.

- Incoming Dead-Front Compartment – Contains bushing wells that accept load-break bushing well inserts. In addition to bushing wells, the dead-front compartment contains three parking stands, a ground bus, and a hinged Lexan viewing window. The hinged Lexan viewing window allows for viewing of blown fuse indictors, and when opened, provides access to the capacitor fuses.

- Live-Front Compartment – Contains a full-width silver plated copper ground bus, capacitor switches, control power transformer, transient inrush reactors, capacitors, capacitor fuses, and associated bus and bus support insulators. These components are all removable from this compartment. Rodent guards are located on the bottom of this compartment.

The overall dimensions shall be 96” x 68”. The access doors shall be on the 96” side.

The enclosure shall be outdoor, weatherproof, free standing, self-supporting, and shall be constructed of minimum 12 gauge steel for all structural panels. The enclosure shall meet or exceed the latest revision of ANSI C57.12.28 "Padmount Equipment Enclosure Integrity." Included in this specification are the requirements for enclosure tamper-proofing and coating system performance.
The enclosure shall be of continuously welded construction to maximize strength, minimize weight and inhibit corrosion. All seams shall be ground smooth to present an attractive appearance. A structural frame and bolted sheet metal is not acceptable.

All ventilation louvers on the enclosure shall be backed with a stainless steel mesh and washable filter. The louver design shall prevent the entry of foreign objects such as sticks, rods, or wires.

The enclosure shall have a finish coating conforming to Munsell designation, 7.0 GY3.29/1.5 padmounted green.

The roof of the switch shall be crowned to ensure proper water drainage. The inside surface of the roof shall have a coating of "no-drip" compound to prevent condensation.

The bottom panel of the enclosure shall be of corrosion resistant material.

The base of the enclosure shall have a minimum one inch flange around the entire bottom to facilitate cleat clamping and shall provide for flush mounting on a flat, rigid mounting surface.

Removable steel lifting plates consisting of 1/2" steel shall be located at each corner and shall allow for balanced lifting.

All access doors shall have pad lockable three-point latching with a handle to provide for a locking device. All access doors shall be fastened with a device that requires a pentahead tool to permit unlatching the door only after the padlock has been removed. This pentahead device or bolt shall be coordinated such that the padlock may not be inserted into the hasp until the access door is fully latched and the pentahead device is secured. The pentahead bolt shall only be operable with the padlock removed.

All pentahead bolts and associated threaded receptacles, hinges, hinge pins, internal fastners, parking stands and permanent lifting provisions shall be AISI type 304 stainless steel or material of equivalent corrosion resistance.

The doors shall be flush when closed and removable in the open position. All doors shall be equipped with door stays to hold doors in the open position.

Thermostatically Controlled Strip Heaters shall be supplied in all non-ventilated compartments. When determined by the manufacturer, a thermostatically controlled fan or ventilator shall be supplied.

The incoming dead-front compartment area shall be separated from the live-front compartment by a mechanical barrier. If the barrier is metallic, it shall be insulated and there shall be a minimum 7 inch phase to ground clearance between it and any energized conductors to prevent inadvertent contact between the high-voltage parts and the metal barrier.

In the incoming dead-front compartment, a ¼ inch clean acrylic or Lexan viewing window shall be removable to gain access to the power fuses.

The capacitor support member on the frame shall tilt outward allowing the removal of each capacitor unit. The capacitor support will be able to contain 100 KVAR, 200 KVAR, 300 KVAR, or 400 KVAR units.

The live-front compartment shall be protected with a full coverage, removable barrier. The removable barriers shall permit; ready installation and removal of capacitor units; inspection and maintenance of capacitor switches; control transformer inspection and removal. When a barrier is installed, there shall be a minimum clearance of 2 inches between any live part and the adjacent barrier surface. The material used for the insulating barriers shall maintain its insulating qualities in all weather conditions to which the capacitor bank may be subjected.

The outer insulation barrier shall be a minimum 3/16 inch thick fiberglass reinforced, polyester laminated or equivalent. The interior barriers shall be ¼ inch clear acrylic or Lexan, flush closing, and held closed by mechanical interlocking.

The enclosure should have indication of the status of the capacitor bank (i.e. open or closed) using external indication lights clearly viewable from the outside that should be of LED (Light Emitting Diode) type, ideally 7-segment LED lamps of type LEDTRONICS model RPLB-030X.

Incoming Dead-Front Compartment

Three 200 Amp apparatus bushing wells, meeting IEEE 386, shall be provided for connecting and terminating incoming cables. Primary bushings shall be a two-piece design with universal bushing wells and load break bushing well inserts, rated for 8.3 kV/14.4 kV. Provisions for an insulated bushing (parking stand) shall be included for each bushing.

The bushing wells in the incoming dead-front compartment shall be located no less than 7.5 inches from the edge of the cabinet. The bushing wells shall be spaced 11 inches apart, with parking stands located 4.5 inches from each bushing.

Bushing wells shall be externally clamped and field replaceable.

Bushing well studs shall be field replaceable.

Sensor Requirements

The automatic capacitor bank shall be equipped with the necessary sensors to meet the requirements of this specification. Sensors include but may not be limited to the following:

- Phase PTs
- Neutral Current Transformer or Neutral Voltage Transformer

The output from three current transformers will be made available from the adjacent switch gear, load side bus. Capacitor bank will be equipped with shorting blocks for CT circuits at the CT circuit connection point.

SCADA Input/Output Requirements

The Automatic Capacitor Bank SCADA system shall be equipped but not limited to the following I/O.

Table 1 - *SCADA I/O Requirements*

Name	Type	Functional Description
Stage 1 On	Indicator/Output	Indicates if Stage 1 is on
Stage 1 Off	Indicator/Output	Indicates if Stage 1 is off
Stage 2 On	Indicator/Output	Indicates if Stage 2 is on
Stage 2 Off	Indicator/Output	Indicates if Stage 2 is off
Data Acquisition Parameters	Output Via DNP 3.0 using RS-232, Ethernet, or both.	Three Phase Voltage, Average Voltage, L-G Voltage, L-L Voltage, Phase Currents, Voltage Unbalance, Current Unbalance, Phase Kvar, Total Kvar, Phase Power Factor, High Voltage Threshold, Low Voltage Threshold, Kvar Upper Threshold, KVAR Lower Threshold, etc…
Neutral Unbalance Alarm	Indicator/Output	Provides warning against a blown capacitor fuse condition on each phase. Each stage of the bank shall be equipped with this indication.
Neutral Unbalance Trip	Indicator/Output	Provides indication that bank tripped on a blown capacitor fuse condition on each phase. Each stage of the bank shall be equipped with this indication.
Over-Voltage Alarm	Indicator/Output	Provides indication of an over-voltage alarm
Over-Voltage Trip	Indicator/Output	Provides indication that the capacitor bank tripped on Over-Voltage

Control Compartment and Controller

A low profile three phase two-stage capacitor switching controller shall be provided. The controller should be comparable to SEL 734B. The controller shall have a Local / Remote control permitting the operation of the capacitor bank only in the selected state. The controller shall monitor the information below and shall be able to provide this information to a Telvent RTU via a DNP 3.0. The following shall be monitored by the controller:

- Voltage, per phase & average
- Line Load Current, per phase & average
- Real Power, per phase & total
- Reactive Power, per phase & total
- Power Factor, per phase and total
- Voltage & Current Unbalance
- Frequency
- Individual and Total Harmonic Distortion on Voltage & Current Inputs up to 15th harmonic

At a minimum, the three phase controller shall be capable of the following functions:

VAR controller - to automatically turn the bank on/off based on VAr load. The auto controller is only allowed to control the bank when it is not being controlled by the SCADA system.

Voltage controller - to automatically turn the bank on/off based on system voltage. The auto controller is only allowed to control the bank when it is not being controlled by the SCADA system.

Loss of Voltage – to automatically turn off the bank(s) upon loss of voltage. This function must remain functional even if there is a loss of control voltage.

Each stage shall be equipped with a single phase over-voltage relay that protects the capacitors as well as the system equipment from over voltages that may be present during light loads.

A time delay of 5 minutes shall be provided to prevent the energization of a capacitor bank stage for each mode of operation (manual, auto, SCADA). When switching between local, auto and SCADA control position on any stage, the corresponding stage shall not be energized in less than 5 minutes.

A maximum number of a capacitor bank stage operation over the course of 24 hours period that the controller can perform shall be provided. If this maximum value is reached, the bank will not be used by the controller until the 24 hour period has elapsed.

Two sets of auxiliary switch contacts per switch shall be provided on the controller for SCADA control / remote status indication (2 Open, 2 Closed per switch). The controller shall be compatible with a TELVENT RTU and DNP 3.0.

All low voltage controls (where practical) shall be isolated from the high voltage compartments. All controls

shall be accessible while the bank is energized. The control compartment shall form 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 high voltage live-front or dead-front compartments. The control compartment shall be equipped with a swing out panel to allow access to panel mounted controls.

All control wires that connect to components inside high voltage compartments shall be enclosed in metal/PVC conduit or wire troughs that are formed as part of the capacitor bank.

The PT's and other devices required to provide SCADA and automatic control signals as outlined in Table 1 of the SCADA Input/Output Requirements.

External 120/240 V AC power supply will be made available for control power. Capacitor bank will be equipped for any additional power conversions required (DC, lower voltage).

A 20 amp convenience GFCI outlet shall be provided in the control compartment for local power.

Capacitor bank will be equipped with an Emergency Stop button that will open all switches immediately. The Emergency Stop button will be hardwired in the control circuit and will have capability of operating independently from other devices.

The bank shall be provided with a maintenance interval timer that can be set to alert utility personnel of a maintenance requirement.

Phase and Ground Bus

All phase and ground bus shall be silver plated copper for maximum conductivity and corrosion resistance. The copper shall be CA110 Square edge, hard temper per ASTM B187. Bolted copper-to-copper connections shall be made with 3/8" – 13 stainless-steel bolts with two stainless steel flat washers, one under the bolt head and one under the nut and with a stainless steel split lock-washer between the flat-washer and the nut. The bus shall be rated for the maximum capacity of the bank.

The bus supports, bus, and interconnections shall withstand the stress associated with the available short-circuit current at the capacitor bank.

The ground bus shall span the full width of the enclosure and shall be bonded to the enclosure walls. The ground bus shall provide a 3/8 inch copper rod in the primary cable entrance compartment to provide a means of attaching a remote ground clamp. Grounding provisions to accept two 1/0 stranded copper ground leads at each end of the enclosure shall be provided for ground grid connections.

Overcurrent Protection

Each capacitor in the bank shall be protected with a high voltage current limiting fuse (CLF) on the line side of the capacitor switches. The CLF's shall be full range and shall be equipped with blown fuse indicator per

phase. The manufacturer shall provide the fuse mountings, fuses, end fittings (including silencers) and a fuse removal tool with the cabinet.

The blown fuse indicators shall be shall be visible through a hinged Lexan access panel from within the dead-front compartment. This hinged access panel shall provide for hot-stick replacement of the fuses after the incoming power conductors are disconnected and placed on the parking stands.

The fuse mountings shall be vertically mounted with 45 degree disconnect opening. The fuse removal tool shall be usable with a standard hot stick.

Line side fuses shall be full range current limiting McGraw Edison NXC fuses. Approved fuse sizes are:

Bank / Stage KVAR	Fuse Size
300 KVAR	NX 18C
600 KVAR	NX 40C
900 KVAR	NX 65C
1200 KVAR	NX 80C

Each stage shall be equipped with a blown fuse detection system that will alert personnel at the capacitor bank and also via SCADA of a blown fuse or fuses. It consists of a meter relay and a neutral current sensor. The meter relay has two individually adjustable points, one to alarm and one to trip the bank off-line for voltages that can damage the remaining "healthy" capacitors.

Transient inrush reactors

Transient inrush reactors shall be provided on each stage of the capacitor bank to limit the magnitude and frequency of inrush currents due to back-to-back switching operations. The reactors shall be designed to reduce noise, promote heat dissipation and provide protection in harsh environments. The supplier shall size the reactors to limit the rate-of-rise of the capacitor stage inrush current (di/dt) to 3.6×10^7 amps/second. Calculations shall be provided to confirm the supplier's claims. The inrush reactors shall be rated for at least 135% of the nominal current rating for the power capacitor stage. If expansion capability is included, the inrush reactors shall be rated for at least 135% of the nominal current rating for maximum capacity of the stage. The reactors shall be a Cooper Power Systems type CCM 13B1 or equivalent.

Lightning/Surge Arresters

The capacitor bank shall be equipped with 10 kV, polymer, heavy duty, distribution class surge/lightning arresters. Approved arrester manufacturers are Joslyn and Ohio Brass.

Vacuum Switches

The capacitor bank stages shall be controlled by three single phase, gang-operated, vacuum switches per stage that have been tested for capacitor switching in accordance with ANSI Standard C37.66 and the

maximum voltage rating of the bank. The switches shall be designed for capacitor switching and shall meet or exceed the electrical ratings shown above plus the following ratings:

Continuous Interrupting Current:	200 Amps
Symmetrical One Second Current:	16,000 Amps *

*Current limiting fuses may be considered if data is presented to confirm the fuse/switch system's rating. Electrical ratings shown assume the use of 200 amp elbows for all connections and the application of full range current limiting fusing as shown on page 6 of this specification.

Vacuum switches may be motor operated or solenoid operated.

The control system shall prevent the vacuum switches from operating more than once in a 5-minute period.

The vacuum switches shall have 120 volt single phase 60 HZ operating mechanism. All switch controls and aux. contacts shall be wired to a utility grade terminal board in the control panel, with No. 14 AWG copper conductors. The terminal board shall have a protective plastic insulating terminal covers.

The switches shall be furnished with a means of hot stick operating the energized switch prior to removing the fuses and grounding the capacitors.

Switch Status Lights shall be provided in the control compartment to clearly identify whether each switch is open or closed, without removal of any front panel(s). A SCADA indication of the status of each switch per phase shall be provided.

Capacitors

The capacitor bank shall be equipped with all-film, low loss, double-bushing capacitors. The capacitors shall be designed, manufactured, and tested to meet and/or exceed all applicable NEMA and ANSI/IEEE standards. The capacitor units shall be filled under vacuum with a biodegradable type liquid dielectric and hermetically sealed. The dielectric fluid shall not contain Polychlorinated Biphenyls (PCB's) or any toxic substance prohibited by the Environmental Protection Agency.

Each capacitor shall contain internal discharge resistors to reduce the stored voltage to 50 volts or less within 5 minutes from disconnection of power.

The capacitors shall be connected in ungrounded-wye and shall be protected from sustained over voltages due to capacitor unit failure or system ground faults. The bank design shall allow for grounding the neutral point of the capacitor bank if desired.

The pad-mounted bank shall be designed to hold 6 capacitors per stage. When only three capacitors are being utilized per stage, space and provisions for three additional capacitors, fuses, and all necessary components, shall be provided. Provisions shall include the following at a minimum:

- Weld-on studs for mounting future capacitors.
- Phase bus, neutral bus, and fuse mounts shall accommodate or be supplied for the future expansion.

The capacitors shall be horizontally mounted and accessible from the live-front compartment.

The manufacturer shall certify that the capacitors and the oil/fluid are PCB free. This will be indicated on the capacitor nameplate.

Nameplate

A nameplate shall be permanently attached to the interior of the control compartment. The nameplate shall as a minimum contain the following information:

- Manufacturer
- Month and year of manufacture
- Serial Number
- Kvar rating of bank
- Voltage rating of bank
- Weight
- All oil/fluid filled components shall have nameplate marking that certifies the oil was classified no-PCB's according to Federal Regulations at the time of manufacturer.

Safety Decals

All required safety decals shall be provided including:

- "Danger – High Voltage" and "Wait 5 minutes after capacitors are de-energized before entering' will be placed on door barriers of the live-front compartment.
- "Do not switch with elbows" will be placed in the incoming dead-front compartment.

QUALITY ASSURANCE

The manufacturer must provide their written quality policy with their bid.

The capacitor bank and all components shall be subjected to and pass all production tests as required by all industry standards mentioned above. Certified test reports shall be furnished for all production tests.

REQUIRED INFORMATION

The supplier shall provide a cut sheet on the vacuum switches with their quotation.

The supplier shall provide a cut sheet on the capacitor switching controller with their quotation.

The supplier must state all exceptions in their quotation.

Upon request by BED, the supplier shall provide a list of utility customers that have purchased similar capacitor banks.
Upon issue of a purchase order, the supplier shall provide 3 copies of approval drawings. The submittals shall include:

- Installation Instructions
- Single Line and three line diagrams
- Detailed wiring diagrams
- Detailed control schematics
- Pad and cable entry drawings
- Drawings showing component layout
- Data sheets for all internal components
- Material listing
- Time coordination plots between capacitor fuses, main disconnect fuses, case rupture curves, and upstream overcurrent protective devices. Damage curve for the capacitor supply cables shall be coordinated with upstream overcurrent protective device.
- Upon approval of above, a digital copy on CD ROM in .DWG or .DXF format shall be provided.

SHIPMENT

Quotes are to be FOB factory, freight allowed.

WARRANTY

Suppliers must offer a minimum 1-year warranty and have available extended warranty programs.

Exceptions to this specification: _____

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_____

_____