Instruction Booklet **IB158008EN** Effective December 2015

AutoVAR medium voltage automatic power factor correction capacitor banks commissioning, operations, and maintenance manual

Contents

Powering Business Worldwide

⚠ WARNING

FAILURE TO FOLLOW ALL SAFETY PROCEDURES FOR THE MV AUTOVAR CAPACITOR BANKS MAY CAUSE DAMAGE TO THE EQUIPMENT AND/OR PERSONAL INJURY.

⚠ WARNING

INCOMING POWER SHALL BE DISCONNECTED BEFORE PERFORMING ANY WORK ON THE UNIT.

⚠ WARNING

AFTER ALL RIGGING, SETTING, AND WIRING HAS BEEN COMPLETED AND BEFORE THE POWER TO THE AUTOVAR IS ENERGIZED, THE INTERIOR OF THE UNIT SHALL BE CLEARED OF ANY METAL EQUIPMENT, METAL SHAVINGS, TOOLS, AND OTHER DEBRIS.

⚠ WARNING

ONLY QUALIFIED PERSONNEL SHALL HAVE ACCESS TO THE ENCLOSURE INTERIOR. ENCLOSURE DOORS SHALL BE LOCKED AT ALL TIMES IF NOT BEING SERVICED.

⚠ WARNING

CAPACITORS MAY RETAIN RESIDUAL VOLTAGES THAT CAN BE LIFE THREATENING. AFTER DISCONNECTING POWER, WAIT 10 MINUTES BEFORE ENTERING THE UNIT. ALL EQUIPMENT BUSES MUST BE MANUALLY GROUNDED BEFORE WORKING ON EQUIPMENT. APPROPRIATE HIGH VOLTAGE PROTECTIVE CLOTHING AND GLOVES SHALL BE USED WHEN GROUNDING. AFTER OPENING MAIN SWITCH, CLOSE GROUND SWITCH. ALLOW 10 MINUTES BEFORE OPENING ENCLOSURE DOOR. TEN MINUTES AFTER CLOSING THE GROUND SWITCH CLOSE THE VACUUM SWITCHES MANUALLY SO THAT ALL THE STAGES ARE EFFECTIVELY GROUNDED. BEFORE CLOSING THE ENCLOSURE DOOR MANUALLY OPEN ALL THE VACUUM CONTACTOR.

⚠ WARNING

AFTER THE CAPACITORS HAVE BEEN DE-ENERGIZED FOR 10 MINUTES AND BEFORE TOUCHING ANY BARE MV COMPONENT INSIDE THE UNIT: FOR POSITIVE MEANS TO DISCHARGE THE CAPACITORS SHORT THE CAPACITOR TERMINALS AND GROUND THE CAPACITOR UNIT TO THE GROUND BUS USING AN INSULATED HOT STICK AND GROUND STRAP.

⚠ WARNING

AVOID PERFORMING ANY WORK ON ENERGIZED EQUIPMENT IN INCLEMENT WEATHER. WET WORKING CONDITIONS ARE EXTREMELY HAZARDOUS WITH THIS EQUIPMENT.

⚠ WARNING

DO NOT SWITCH CAPACITORS ON-OFF-ON IN LESS THAN 200 SECONDS. DO NOT CYCLE CAPACITOR MODE SELECTOR SWITCH MANUAL-OFF-AUTO IN LESS THEN 200 SECONDS.

⚠ WARNING

REFER TO THE EQUIPMENT DRAWING AND OUTLINE DRAWINGS BEFORE INSTALLING AND COMMISSIONING THE UNIT.

⚠ WARNING

COORDINATE ALL ON-SITE WORK WITH CUSTOMER AND CONTRACTOR. FOLLOW ALL SAFETY / LOCK OUT / TAG OUT PROCEDURES. WEAR ALL PERSONNEL PROTECTIVE EQUIPMENT AS REQUIRED.

Handling and installation instructions for medium voltage metal-enclosed capacitor banks

General

The following handling and installation instructions are intended to help customers install the medium voltage metal-enclosed capacitor banks properly and efficiently. Handling and installation instructions are only recommendations. They do not relieve the purchaser, customer, installer, or contractor from full responsibility for proper inspection, handling, and installation. Failure by the customer to comply with handling or installation instructions will void the capacitor bank warranty.

Inspection

At the time of delivery the customer shall be responsible for inspecting all sections of the equipment for damage during transit. Both the inside and outside of the equipment must be inspected. If any damage has occurred it should be noted on the delivery receipt prior to signing acceptance. If damage has occurred a claim should be immediately filed by the customer with the delivering carrier. A minor paint scratch or a minor dent can be touched up or repaired at the site.

Short-term storage

If a capacitor unit is not energized, store it in a climate-controlled environment with adequate air circulation so that it is protected from dirt, air born contaminants, moisture/humidity, water, and chemicals. The storage temperatures should be from 0 °C (32 °F) to 40 °C (104 °F). The environment humidity should be less than 70%.

If the storage area is cool and/or damp, space heaters should be provided to prevent condensation inside the Automatic Capacitor Bank.

Evaluate and if necessary clean the dust/air filter.

For NEMA® 3R units, NEMA 3R rating only applies once independent sections have been connected and the unit has been completely assembled.

Long-term storage

Store the equipment in a dry, ventilated location protected from dirt, airborne contaminants, moisture/humidity, water, and chemicals. The storage temperatures should be from 0 °C (32 °F) to 40 °C (104 °F). The environment humidity should be less than 70%.

Stored equipment could be protected by a water-resistant cover such as a tarp or plastic providing effective protection against dust, dirt, and water, etc., taking care as to not impede the natural ventilation.

Putting a capacitor bank into service after 6 months requires that the unit be subjected to INSULATION RESISTANCE AND CAPACITANCE measurements. Note: INSULATION RESISTANCE SHOULD ONLY BE PERFORMED BETWEEN TERMINAL AND GROUND. Ensure the control power fuses are disconnected/isolated during and from the test. The test readings should be at least 200 Mohm or greater. If the value is found to be lesser, take steps to trace and eliminate moisture from the unit.

Evaluate and, if necessary, clean or replace the dust/air filter.

After short-term and long-term storage

Follow instructions of individual components such as contactors and circuit breakers.

For control power circuit breakers

Remove dust, dirt, soil, grease, or moisture from the surface of the circuit breaker using a lint-free dry cloth, brush, or vacuum cleaner. Do not blow debris into the circuit breaker. If contamination is found, look for the source and eliminate the problem.

Switch circuit breaker to ON and OFF several times to be sure that the mechanical linkages are free and do not bind. If mechanical linkages are not free, replace the circuit breaker.

Check base, cover, and operating handle for cracks, chipping, and discoloration. Circuit breakers should be replaced if cracks or severe discoloration is found.

Check circuit breaker mounting hardware and tighten if necessary.

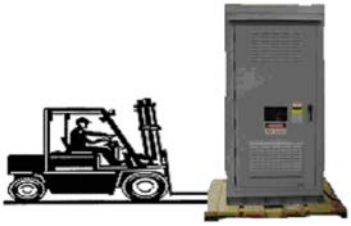
Check area where the circuit breaker is installed for any safety hazards, including personal safety and fire hazards.

Exposure to certain types of chemicals can cause deterioration of electrical connections.

Moving

1. To move 106-inch-long shipping pallets use fork lifts on both ends of equipment on wood pallet. Do not use fork lift if the equipment has been un-mounted from the wood pallet.

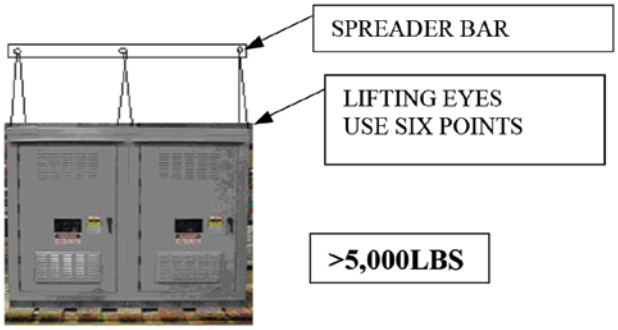
2. To move 65-inch-long shipping pallets use 4-wheel fork lift on any one end of the equipment on wood pallet.



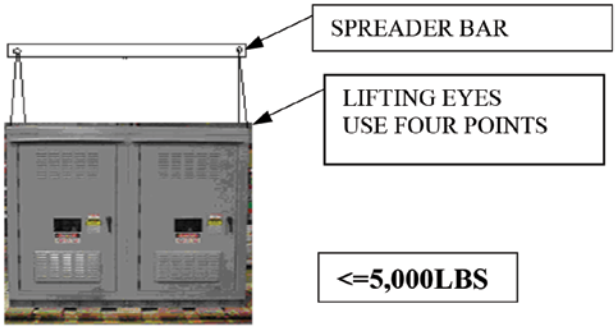
3. The maximum ‘double’ shipping section dimension (with wood pallet and lifting eyes included) is 106 inches wide x 65 inches deep x 99 inches high. See shipping section drawings.
4. The maximum ‘single’ shipping section dimension (with wood pallet and lifting eyes included) is 65 inches wide x 65 inches deep x 99 inches high. See shipping section drawings.
5. Do not drop the equipment.
6. Do not allow hard impact from tools and handling equipment.
7. Never use cables or chains around the equipment. Use the lifting eyes to move the equipment.
8. Never fork lift equipment without the wood pallet.
9. Do not tilt the equipment.
10. Use of rollers to allow equipment to roll on base channel is permitted.
11. Weights shown on drawings are estimated weights. Refer to shipping papers for actual weights of shipping sections.

Lifting

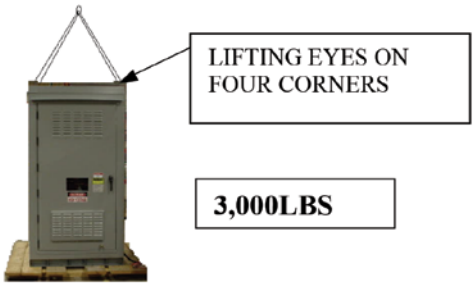
1. For 90-inch-wide shipping section use spreader bar and lines attached to appropriate lifting eyes to move equipment.
   a. For 90-inch-wide shipping sections weighing more than 5,000 lb use all six lifting eyes to lift the shipping section as shown below.



   b. For 90-inch-wide shipping sections weighing up to 5,000 lb use all four lifting eyes to lift the shipping section as shown below.



2. For 45-inch wide shipping section use lines attached to all four lifting eyes to move equipment.



Installation

1. The equipment requires a concrete slab for continuous bottom support.
2. Locate and line-up all shipping sections. Use shipping section hardware provided to bolt the shipping sections together on top and at bottom base channel sides. Each shipping section has gasketed roof shipping split cover plates. Slide the shipping split roof covers to match all six holes on the top roof sheet. Use bolts and gaskets supplied to bolt down the shipping split cover on six locations per each shipping split.
3. Install the shipping split main bus INSULATED copper splices and ground bus copper splices before finally anchoring the equipment to the concrete slab. The main bus splice plates must be insulated. Verify that the main bus splice plate insulation is not damaged during installation.
4. Anchor the base channel to the concrete slab with anchor bolts and hold down hardware. Anchor bolts and hold down hardware are supplied by the customer. See equipment drawing for details. Use the cut-out from the equipment drawing as reference for anchoring.
5. The customer can use either external anchor clips or use the holes provided in base channel to anchor this equipment.
6. Each 45-inch-wide section front and rear base channels have four 0.5-inch-diameter holes. Depending on the length of the assembly use appropriate points for anchoring locations through out the entire line-up. The factory recommends a minimum of four (total front and rear base channel) anchor points per each 90-inch length of equipment.
7. After all shipping split connections and anchoring is completed use outdoor weather proof silicone caulking provided to caulk all shipping split joints.

IMPORTANT

CAULK THE AREA AROUND EACH OF THE SIX BOLTS ON THE TOP SHIPPING SPLIT ROOF COVER.

8. Connect the respective male and female control wiring plugs between each shipping split sections. Match the male and female plugs using the wire marker identification.
9. Terminate customer's shielded power cables in the main incoming section. Hi-pot the customer's power cable for insulation integrity. Stress cones are required.
10. Terminate customer's control wires per equipment drawing in the control panel. Route customer's control cables in a protective tubing and tie down the control cables away from live parts. Maintain a separation of 24 inches between control wires and any live part.

Section 1: Site preparation and installation overview

Site preparation—prior to delivery: referencing equipment drawings

1. Obtain contact for local utility and review project application with customer/contractor. Coordinate all on-site work with customer/contractor.
2. Install capacitor bank per equipment drawings. Allow for minimum of 5 feet of "working clearance" in front of Unit (Metal Enclosed Power Capacitor Bank). Units are typically front accessible. Refer to equipment drawing if rear access is required.
   a. If Unit has integral, main fused disconnect, then the Feeder may be 'tapped' to distribution bus by complying with NEC® Article 240.21 and Article 460 Section II and all applicable NEC codes.
   b. If Unit does not have main fused disconnect, provide "capacitive load rated", short circuit protected load break disconnect, sized a minimum of 135% of Unit full load amperes (FLA). (Eaton recommends 150% of FLA. For harmonic filter capacitor banks size feeders at least 150% of FLA).
   c. Unit fed from overhead lines must have lightning arresters. Unit fed from overhead lines must have an upstream circuit breaker with overcurrent protection.
   d. Size all cables, switches, circuit breakers, and fuses a minimum of 135% (150% x FLA is recommended) of full load amperes of the capacitor bank. Circuit breaker trip and fuse characteristics should coordinate with capacitor protection fuses installed in the unit.

⚠ WARNING

COORDINATE ALL ON-SITE WORK WITH CUSTOMER AND CONTRACTOR. FOLLOW ALL SAFETY / LOCK OUT / TAG OUT PROCEDURES. WEAR ALL PERSONNEL PROTECTIVE EQUIPMENT AS REQUIRED.

3. Provide feeder raceway/cable(s) routing to Unit(s).
4. Provide Main Current Transformer (MCT) secondary wires in metallic conduit/shielded cables to same location as feeder conduit.
5. Provide controls conduit for remote controls and alarm monitoring to same location as feeder conduit.
6. Provide concrete pad and grounding grid. Provide #2 ground equipment bonding conductors on opposite ends of Unit. Connect the ground conductors to the unit ground bus. Connect ground bus using customer provided lugs.
7. Do not place Unit closer than 10 feet to roadways or parking areas. Use chain link fencing or concrete filled steel bollards to protect from damage as needed.
8. In very arid environments, where daytime temperatures will exceed 104 °F (40 °C), some form of shading should be provided for Unit(s) from direct rays of midday/afternoon sun.
9. MCT should be appropriately sized and approved for the application by a qualified engineer. CT secondary current range should be at least 0.5 A to 5 A during normal plant load cycle. The MCT shall have 5 A secondary, Metering Class B0.1 5 VA or C50 class and 5 VA minimum burden. Install MCT on Phase 'A' (or 'L1'). If installed on other phases change the phase compensation angle in the power factor controller BLR-CM. If a 600 V insulated CT is used, it should be appropriately sized and approved for the application by a qualified engineer. Polarity 'dot' should be toward utility.

⚠ WARNING

WHEN INSTALLING MCT, BE SURE THAT TERMINALS ARE SHUNTED TO AVOID SHOCK HAZARD.

Installation overview—delivery and installation of unit(s)

1. Refer to the handling and installation instructions supplied with the unit. Unwrap the enclosures and inspect for damages. Any damages shall be documented and transmitted to Eaton immediately.
2. 'Rig' the enclosures and set in place on concrete pad. Unit(s) are typically shipped in maximum 90-inch lengths.
   a. 2 x 3/4-inch 'Eye' bolts have been furnished on the four corners of each enclosure for lifting by crane.
   b. Unit(s) are mounted on 4-inch C channels. Use forklifts with unit mounted on pallets. Use Extended forks to lift unit on wood pallets.
3. Assemble Unit(s) on concrete pad. Refer to equipment drawings before starting any work. Verify/position Incoming section, with floor cutout, over conduit 'throat'. Assembly 'kits' are inside the Incoming section. There are four, 3/4-inch bolts to install at corners of enclosures to bolt adjoining enclosures together. Two are in 'webbing' of C channel and two are inside top corners of enclosures. Install gasketing strip between enclosures along top edge before drawing enclosures together. Install end 'skirts' on ends of C channel. Skirts and bolts are in incoming section.
4. Anchor each enclosure at four points near corners with concrete anchors and cast or steel hold down anchor clamps. All anchoring hardware, anchor bolts, and anchor clips are to be supplied by customer/contractor based on the on-site structural requirements.
5. Finish conduits into incoming section and bond conduits to ground bus with minimum #6. Provide bonding bushings on each conduit.
6. Installing power cables
   a. Verify that main feeder power is not energized and that the upstream feeder disconnect has been locked out in open position.
   b. Install power cables from the capacitor feeder breaker/switch to capacitor bank main incoming section per the equipment drawing. Size and terminate power cables per qualified engineer and local codes. See equipment drawings for full load amp rating. Care should be taken to mark 'phases' on power cables with particular care to note which cable comes from phase that MCT is mounted on. By convention, this is Phase 'A'. Shielded cables must be kept at least 8 inches away from any live parts in Unit.
   c. If aerial cable is being used, install termination bushings on Incoming section and terminate. Care should be taken to properly support these cables. System ground conductor (minimum #2) must be bonded to ground system at pad and run in conduit.
7. If ordered and supplied, install alarm strobe on top (or side) of incoming enclosure. Wires are coiled at top of enclosure. Use watertight 3/4-inch conduit hub, Meyer's or equivalent.
8. Remove all packing and temporary bracing materials (wood and cardboard) from Unit(s). Remove all loose materials.

9. When supplied install the "GRAY" insulated bus bar splices for main bus between each shipping split. Make sure that splice bus bar is installed below the existing bus bar and that the bolt head should be on top. THE GRAY INSULATING TUBE IS REQUIRED ON EACH BUS BAR BETWEEN SHIPPING SPLIT. IF THE GRAY INSULATING TUBES ARE MISSING PLEASE CONTACT THE FACTORY. DO NOT ENERGIZE THE UNIT WITHOUT THE GRAY INSULATING TUBES ON EACH MAIN BUS BAR BETWEEN EACH SHIPPING SPLITS.
10. Install the ground bus bar splices between each shipping split.
11. Connect the male and female control wiring plugs between each shipping splits. All wires are labeled. Verify that the wire tags on both sides of the connector match.
12. Remove the eye bolts on both sides of each shipping split and slide the metal cover pan installed on roof over the gap between each shipping split. Use bolts and washers supplied to bolt the shipping cover pan over the shipping split gap. For all types of enclosures use adequate silicone to weatherproof and seal all sides of the cover pan. Repeat this procedure for all shipping splits.
13. When applicable connect the CT secondary leads between individual stages and unit control panel.

Section 2: Electrical system connections

1. Basic electrical connections are as shown on equipment drawings. Size power cables per equipment requirement.
2. Three-phase conductors and the system ground conductors are required. Size phase and ground conductors per the rating of the feeder protection device and NEC tap rule as applicable. Install shielded medium voltage cable. Coordinate cable AWG size and lugs with termination provisions in the unit before installing cables.
3. Useful formulas:

   Voltage Ratings:

   Capacitors for 15 kV Class are normally connected in ungrounded 'WYE' configuration. The equivalent rated phase to phase voltage will be the nameplate voltage (phase to neutral) times √ 3.

   Example: 7.62 kV (L-N) x √ 3 = 7.62 x 1.732 = 13.2 kV (L-L)

   Capacitors for 5 kV Class are normally connected in delta configuration. The capacitors units are rated for Line to Line voltage for delta connected banks.

   Capacitor Nameplate Voltage:

   Rated Capacitor Current = (1000 x kvar) / (√ 3 x Voltage)

   Where: Voltage = Line to Line voltage

   kvar = 3 phase effective kvar rating of capacitors

   If capacitor nameplate voltage is different from system or operating voltage:

   kvar (cap) = Nameplate kvar x (Operating Voltage/Nameplate Voltage)^2

   Example: Applying capacitor bank with nameplate rating of 900 kvar at 13.2 kV on a system with nominal system voltage of 12.47 kV:

   Effective Capacitor Power at
   12.47 kV = 900 (12.47 / 13.2)^2 = 802 kvar

   Effective Capacitor Amps = (1000 x 802) / (1.732 x 12470) = 37.2 A

   Equipment/cable sizing must be at least: 37.2 x 1.35 = 50.2 A

4. Main Current Transformer (MCT) Placement

IMPORTANT

THE PLACEMENT OF THE MCT IS CRITICAL TO THE PROPER OPERATION OF THE AUTOVAR. IMPROPER LOCATION AND PHASING OF THE CURRENT TRANSFORMER (CT) CAUSES MORE STARTUP PROBLEMS THAN ANY OTHER ERROR.

   As shown in **Figure 1**, the MCT must be placed on Phase A of the main plant feeder. Place the MCT so that it 'sees' the entire plant load whose power factor is to be corrected, including the new capacitor bank. The high side of the MCT (polarity mark "H1") must be towards the utility source.

5. MCT secondary wires and connections

   MCT secondary wire size should be appropriately sized and approved for the application by a qualified engineer. See Eaton publication IB157002EN for the CT burden of the BLR-CM controller.

   After the MCT has been placed on the main incoming bus, the interconnects from the MCT secondary should be terminated on the shorting block terminals STB2-K (CT-X1) and STB2-L (CT-X2) (located in the Control Panel located on the main cabinet door). The MCT shorting screw may then be removed.

6. Customer controls and alarm/monitoring connections

   Customer wiring is to be installed to as per equipment drawing and wiring diagrams. Route customer control cables in protective covers inside the incoming section and wire tie the bundle securely maintaining 12 inches of clearance from any live parts. Standard outputs are:

   Dry contact Unit Alarm (RA1 and RA2): Closed = Alarm

   Other Inputs/Outputs are by special request and will be shown on equipment drawings.

7. Torque values

Location	Value
Copper bus terminations	20 lb-ft
Capacitor unit bushing terminals	17 lb-ft
15 kV vacuum switch terminals	15 lb-ft
Surge arrester terminal stud	20 lb-ft
Iron core reactor terminals	20 lb-ft
Air core reactor terminals	20 lb-ft
Power fuse terminals	20 lb-ft
Low voltage control wiring terminals	12 to 18 lb-in

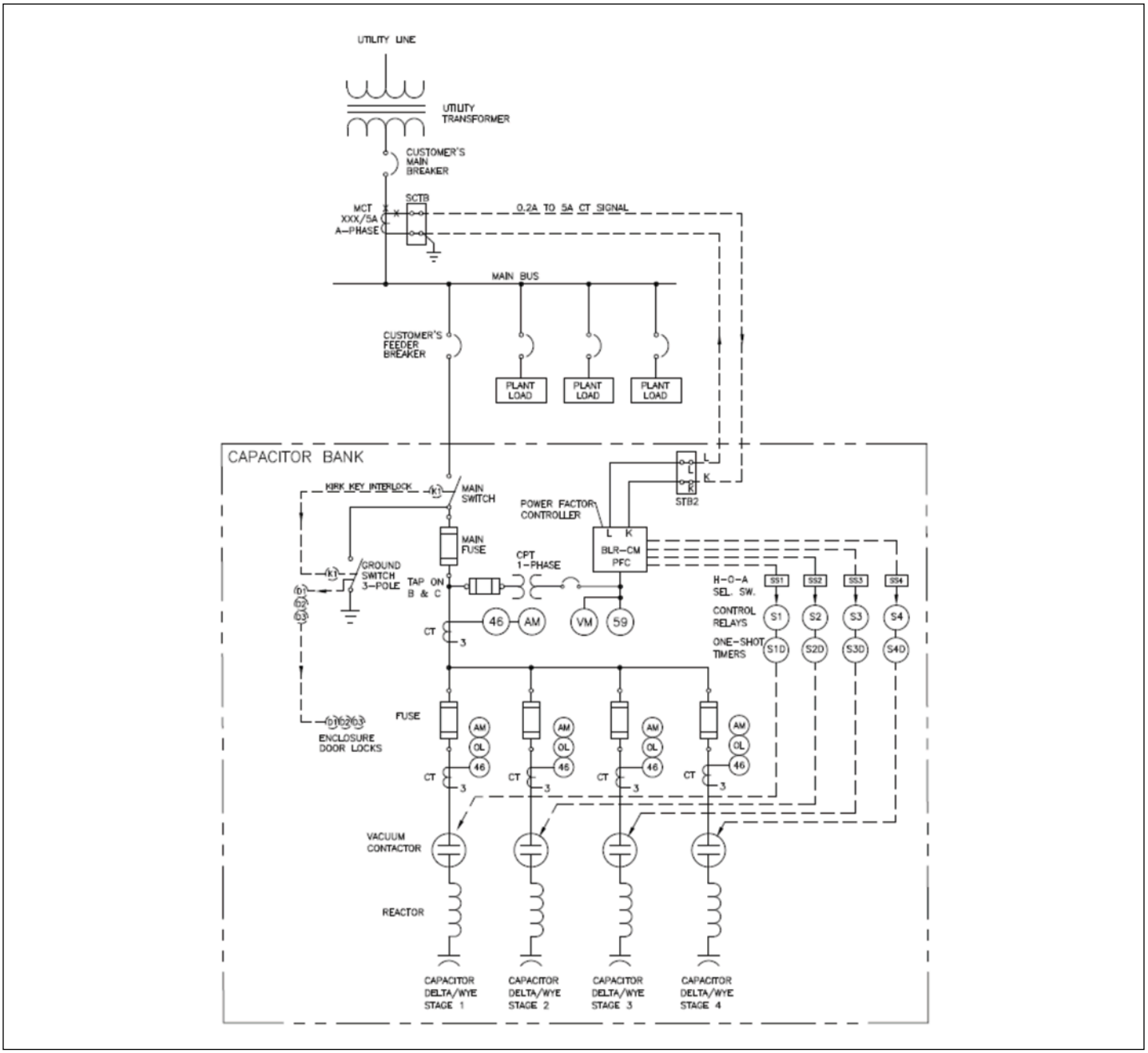


Figure 1. Typical single-line diagram—current transformer placement and connection

⚠ WARNING

THE CT TERMINALS MUST ALWAYS BE SHORT CIRCUITED DURING INSTALLATION, REMOVAL, OR AT ANY OTHER TIME WHEN THE CT MAY BECOME OPEN CIRCUITED. IT IS STILL RECOMMENDED THAT THE CT IS SHORTED BY `JUMPERING' THESE OUTPUT TERMINALS BEFORE DOING ANY WORK ON THE UNIT.

Section 3: Pre-startup checks

Automatic unit instructions are with BLR-CM controller if applicable

1. Kirk Key Interlocks are provided on all units. The interlocks are intended to prevent entry into enclosures when units are energized. Verify the following sequence:

Step	Description
1	Main disconnect (either customer's or unit) 'OPEN'
2	Ground switch 'CLOSED'
3	Wait 10 minutes to allow capacitors to discharge
4	Unlock and open enclosure doors
5	Reverse procedure to close the unit

   Each pair of locks has two keys, one has Warning Tag "DUPLICATE KEY". Before energizing the unit the second set of duplicate keys should be either destroyed or locked up in safe location and to be only used as back-up if the original key is broken.
2. Verify that all cabling and wire connections have been completed to the unit, terminations are appropriately tight, and cables are insulated from mechanical damage.
3. Check interior of unit for any equipment that may have shifted in transit. Check that insulators are not cracked or damaged. Review with factory and reposition or repair as required.
4. Check all power cable terminations within the unit. Main Customer power cable terminations should be torqued to appropriate value.
5. Verify that unit interior is clean of any debris or flammable materials and moisture.
6. Verify that Stage H-O-A control selector switches are set to 'OFF' position.
7. Verify that all CT terminations are tight and secure at all CT shorting blocks. Verify continuity of all CT leads and none of the CT circuits should be open circuited.
8. Check capacitor bank with DC Hi-pot Test set. Perform insulation resistance test on all power components. DC Hi-pot readings from phase to ground should be in Giga-ohms. DC Hi-pot readings phase to phase with capacitors in circuit should be in Mega-ohms. (The capacitors cells are equipped with internal discharge resistors.) Since each capacitor is equipped with an internal discharge resistor across its terminals the DC Hi-pot readings are in Mega-ohms.
9. Perform DC Hi-pot Test from phase to ground: DC Hi-pot voltage should be 2 x rated capacitor bank voltage. The leakage currents should be in low micro-amps.

⚠ WARNING

BEFORE PERFORMING THE HI-POT TEST DISCONNECT THE SURGE ARRESTERS AND REMOVE ALL CPT PRIMARY FUSES.

⚠ DANGER

DC HI-POT AND HI-POT TESTERS PRODUCE POTENTIALLY LETHAL VOLTAGES. USE APPROPRIATE SAFETY PROCEDURES IN CONDUCTING THESE TESTS.

10. At this point the commissioning personnel may elect to power up and test the controls with an external 120 Vac, 60 Hz source and current/voltage secondary injection relay test set.
11. Before applying external control power

    Verify that the main switch is opened, ground switch is closed, all the CPT primary fuses are not installed on Control Power Transformer (CPT), and all secondary CPT wires have been disconnected from the CPT. Temporary 120 Vac power can be terminated on the disconnected secondary lead. Refer to equipment drawings and wiring diagrams before applying temporary power.
12. With temporary 120 Vac external power verify the following:
    a. Verify all vacuum contactors open and close using the H-O-A switch.
    b. Verify all cooling fans operate.
    c. Verify all space heaters operate.
    d. Verify all indicating lights illuminate.
    e. If applicable, verify that the Customer Phase A MCT ratio matches the CT ratio in the BLR-CM pf controller.
    f. Review and verify all BLR-CM power factor controller settings per equipment drawings. Review and finalize the TARGET power factor setting with the customer. The step recognition setting in the controller is typically set in OFF position. Verify each stage kvar is programmed in the controller as per the equipment drawings. Password for BLR-CM power factor controller is "2402".
    g. If applicable, review and verify all Satec® PM130P power meter/relay settings.
    h. If applicable, review and verify all KSR capacitor protection relay settings.
    i. Verify all timers and thermostats are set per equipment drawings.
    j. Verify all capacitor contactors open and close from the BLR-CM power factor controller by using the Manual mode in the controller.
    k. Verify all loss of control/cooling fan/vacuum contactor power circuits operate and trigger an alarm.
    l. See Eaton publication IB157002EN for more information on the BLR-CM controller.

Section 4: Energizing the unit

Automatic unit instructions are with BLR-CM controller if applicable

1. Before energizing the unit, ensure that there is adequate plant load such that minimum 0.25 A flows in the MCT secondary wires for the power factory controller to turn on stages. Verify all stage vacuum contactors are in OPEN position.
2. Do not perform this work in wet weather for units installed outdoors.
3. Coordinate all on-site work with customer/contractor.
4. Remove all temporary 120 Vac external power source, if used, reconnect CPT secondary wires. Re-install the CPT primary fuses.
5. Check all live part connections are tight.
6. Perform a visual inspection of all bus and live parts to ensure no foreign objects have been left inside the enclosure.
7. Install main fuses at main disconnect.
8. Using a DC Hi-pot tester check each phase-to-ground and phase-to-phase for any shorts. Record these readings. Depending upon which components are in the circuit the DC Hi-pot reading should be in high Mega-ohms range.
9. Close enclosure doors and use key interlocks to lock all enclosure doors
10. If ground switch is supplied then unlock and open ground switch. Verify via the viewing window if all three phase blades of the ground switch have opened.
11. Remove lockouts/tagouts on customer main, if used.
12. Close the main switch disconnect switch.
13. Verify that 'POWER is ON' on control panel and some portions of the control circuit shall be energized (Refer to the equipment drawings). After 200 seconds the start delay timer "SD" will time out and then energize the power factor controller BLR-CM and remaining portion of the control circuit.
14. For the first 200 seconds the Unit Remote Alarm RA1/RA2 dry contact will pick up indicating that there is a loss of control power since the SD timer has not timed out.

Section 5: Online testing and commissioning

Automatic unit instructions are with BLR-CM controller if applicable

1. The Unit has been factory tested for correct controls operation. Although wires could have been disconnected in transit, it is assumed that the basic steps are completed and all basic checks have been performed.
2. After 200 seconds (Start Delay 'SD' Timer times out), the Power Factor Controller BLR-CM will turn 'ON'.
3. Check the power factor controller BLR-CM screen and it should display a "smiley" face on the upper right hand corner of the display screen. If it does not display a smiling face then read the message to the left of the face.
   - If message shows I < LIMIT then it indicates there is no current in the MCT secondary loop. Investigate why there is no current in the MCT loop
   - If message shows U <> LIMIT then it indicates that the voltage is out of range. Verify that the VT FACTOR (ratio of the PT) and the NOMINAL VOLTAGE settings are correctly programmed in the controller settings
4. Check the controller display for current and voltage measurements. The current and voltage readings should be ±5% of main powermeter readings if available and assuming balanced loads. If the current and voltage readings do not match the customer's main powermeter then check the following:
   - Verify that the CT FACTOR (Current Transformer MCT ratio) is correctly programmed in the controller settings
   - Verify that the VT FACTOR (Ratio of the PT) and the NOMINAL VOLTAGE settings are correctly programmed in the controller settings

Note: Record the correct CT FACTOR and VT FACTOR on the settings chart drawing and in the customer's copy of the O&M Manual.

5. Check the controller display and it should read (inductive) between 0.60 to 0.99 PF depending on current system parameters/loads. ('i' or 'c' will appear on left side of display). If it power factor displayed is not "i" inductive then change the phase compensation angle in the controller settings so that the correct power factor reading is displayed.
   - MCT leads may be reversed
   - MCT may not be installed on the correct phase
   - MCT H1 polarity may not be facing the utility
   - CPT phases may not be connected to the correct phase due to incoming cables may have rolled
   - Utility phase rotation may not be ABC

Note: There is no need to disconnect any wires to correct this problem. Change the phase compensation angle in the controller setting in 15-degree increments until the correct power factor reading is displayed and it matches with the customer's/utility's main meter power factor. Once the correct phase compensation angle is found record this on the settings chart drawing and in the customer's copy of the O&M manual.

6. The Controller has been factory calibrated based on the design information available. The calibration settings are shown on equipment drawings. Refer to the BLR-CM Instruction Manual to make adjustments for field conditions. Review and verify all BLR-CM power factor controller settings.
7. Check control voltage and record reading. This is directly proportional to system voltage and CPT ratio.

   For example: CPT for 12.47 kV system is rated 12 kV–120 V which means the VT ratio is 100. If the actual system voltage is 12600 V the secondary L-N voltage reading shall be 12600/100 = 126 V.
8. Test Stages manually with H-O-A switches.
   a. Select 'Hand' position 'H' on Stage #1 to turn on the stage vacuum contactor and verify red Stage 'ON' light is on. (Note that every time the H-O-A selector switch position cycles through OFF position a single shot timer becomes active and will not allow the vacuum contactors to switch ON until 180 seconds time delay).
   b. Record current readings on the meter for all three phases if equipped. The current readings should closely match with the rated current as shown on equipment drawings. Current will be proportionally higher or lower with the voltage of the system. Record average current for each phase. The phase currents should be balanced within 3%.
   c. Monitor power factor before and after the stage turns ON. The power factor reading should increase toward Unity when the stage turns ON, assuming sufficient load and inductive load.

d. If currents are not balanced, check the vacuum contactor poles for 15 kV systems and for all systems check CT circuit for Unit's internal CTs, for a loose connection. (For 15 kV systems verify that all three single-pole contactors have closed by observing yellow handle positions on the contactors. These should be visible through windows. When the yellow handle is UP the contacts are closed and when the yellow handle is DOWN the contacts are open.)

e. Turn 'OFF' Stage #1. (For 15 kV systems verify that all three single-pole contactors have opened by observing yellow handles, positions on contactors. These should be visible through windows if equipped.)

f. Repeat steps (a) to (e) for all additional stages, one at a time, and record the current readings for each stage.

g. After checking all stages manually place all stage selector switches in OFF position.

h. It is assumed that there is adequate plant loading to perform the next test. When capacitor stages are turned ON the system voltage will rise.

9. Check controller factory settings to determine if adjustments are needed. See Eaton publication IB157002EN for more information on the BLR-CM controller.

10. Assuming the BLR-CM controller settings are acceptable and reasonable current readings have been obtained in **Section 5.8** follow the steps as shown below:

    a. Place all stage selector switches in 'OFF' position.

    b. Turn OFF control power circuit breaker CB1.

    c. Place all stage selector switches in automatic 'AUTO' position.

    d. Turn ON control power circuit breaker CB1.

    e. After 200 seconds the start delay timer SD timer will time out and power up the power factor controller.

    f. After the power factor controller is powered up it will begin automatically turning the stages ON as needed to reach the target power factor. This process could take 5 to 10 minutes. The controller will attempt to reach the target power factor by using the best available kvar stage combinations.

11. Check current and control voltage and record readings. If Unit appears to be operating within reasonable limits, it can be left in operation.

12. The customer's dry alarm contact RA1/RA2 has a 30 second delay. All alarms are delayed by 30 seconds. Observe the unit for 2 hours for any alarm conditions and take notes of the power factor, current, voltage, and number of operations.

13. If Unit is allowed to warm up (and if outside temperature is not too low), the fans in each enclosure will turn 'ON' at about 85 °F.

Section 6: Troubleshooting guide

Problem	Cause and remedy
No control power	Check circuit breakers in control panel. If breaker has tripped check for short circuits in control wiring.
	Check for loose wiring or loose male and female connectors.
	Check for blown primary fuses on the CPT.
Power factor displayed is not correct or decreases when stages are turned on	MCT polarity is reversed.
	MCT installed on wrong phase.
	MCT installed on incorrect location.
	Loose MCT secondary lead.
	MCT secondary current is very low (<0.05 A).
Controller current displayed is not correct or zero	Check CT ratio setting in controller.
	Check if MCT is bad.
	MCT secondary circuit has been shorted or open circuited.
Stage does not engage	Check interposing control relay and single shot timer.
	Check for loose wiring.
	Check power factor controller settings.
	Check vacuum contactor for open/close.
Phase current unbalance alarm/trip	Check for blown fuse on capacitor or mains.
	Check capacitance for each capacitor.
	Check each single-pole vacuum contactor status and operation.
	Check protective relay settings.
	Check for loose CT wire or connection.
	Check if CT is bad.
Phase overload alarm/trip	Check for blown fuse on capacitor.
	Check for line to ground fault using a DC Hi-pot tester
	Check capacitance of capacitors.
	Check reactor for signs of overheating and discoloration.
Overtemperature alarm/trip	Check the air filters.
	Check thermostat as-found setting.
	Check cooling fan operation.
	Check cooling fan control circuit and thermostat.
	Check reactor for signs of overheating and discoloration.
Control Alarm on controller	Permanent over or under compensation due to stage kvar not available.
	Check settings/contactors/blown fuse/target pf setting not optimized
Voltage display not correct	Check PT ratio in controller and powermeters
Power factor does not change after a stage is switched On	Check MCT location. MCT may be installed on the wrong feeder.
Loss of cooling fan power or loss of vacuum contactor power	Check circuit breaker in control panel. If breaker has tripped check for short circuit in wiring.
	Check for loose male and female connectors.
	Check supervision control relay for failure.
	Check CPT for blown primary fuse.
Blown capacitor fuse	Check for shorted capacitor unit.
	Check for short circuit
	Frequent unexplained fuse blowing may be a sign of parallel resonance condition. Perform harmonic analysis for resonance.

Contact Eaton's Technical Resource Center (TRC) Power Factor Application Engineers at 1-800-809-2772, choose option #4, then option #2, for additional information on troubleshooting.

Section 7: Inspection and maintenance

1. First month (refer to the maintenance/inspection schedule)
   a. Touch up any paint scratches or damage with ANSI 61 Gray paint.
   b. Review and obtain spare parts if not already in stock.
   c. Monitor operation of Unit on daily basis for one week. Keep record of any unusual operating conditions.
   d. At two weeks, inspect the unit for any abnormal conditions.
   e. Once a week, record power factor, control voltage, number of stage operations and current.
   f. Verify operation of customer alarm circuit. Verify that alarm works in facility.
2. Every 3 months (refer to the maintenance/inspection schedule)
   a. Check unit operation, record power factor, control voltage, number of stage operations and current.
   b. Shut down Unit and inspect interior for moisture, dirt, or insects. Clean as needed.
   c. Check and replace air filters. In very dusty environments, air filters may require replacement every month.
   d. Check all cooling fans are operating and air vents are not clogged.
   e. Check Unit for exterior damage or rust. Repair/Touch-up paint as needed.
3. Every year (refer to the maintenance/inspection schedule)
   a. Perform the above listed 3 months checks.
   b. Check and tighten all power connections.
   c. Verify operation of customer alarm circuit and red strobe light (if installed).
   d. Perform visual inspection of all components.
   e. Verify if all LED indicating lights are working.

NOTICE

IF ANY LARGE NONLINEAR LOADS (ADJUSTABLE / VARIABLE SPEED / FREQUENCY DRIVES (VFDS), DC DRIVES, BATTERY CHARGERS, RECTIFIERS, ARC FURNACES ETC.) ARE TO BE INSTALLED IN THE PLANT AFTER INSTALLATION OF THIS UNIT, PERFORM PARALLEL RESONANCE CHECK AND HARMONIC ANALYSIS TO VERIFY THAT THE CAPACITOR BANK WILL NOT BE ADVERSELY AFFECTED.

MAINTAIN AN INSPECTION AND MAINTENANCE LOG USING THE INSPECTION SCHEDULE SUPPLIED WITH MANUAL. CONTACT LOCAL EATON SALES OFFICE FOR ON SITE INSPECTION AND MAINTENANCE SERVICE.

Table 1. Low voltage capacitor bank startup inspection and maintenance schedule

CUSTOMER:		
UNIT SERIAL NUMBER:		
Qtr: Every 3 months Semi: Every 6 months Ann: Every 12 months	C - Clean	P - Touch-up Paint
	F - Check for Open/Damage Fuse	R - Replace parts or component
	I - Inspection of Component/Equipment	S - Apply Silicone Caulk (Outdoor Unit)
	L - Lubricate	T - Test component
	O - Torque Connections	V - Verify Operation

Component	Routine				Service Schedule Years From Installation Date							
	Start-up	Quarterly	Semi-Annually	Annually	2.5	5	7.5	10	12.5	15	17.5	20
Date of Service:												
Service Performed By:												
Air Filters	I	R	R	R								
Alarm Indication/Strobe Lights	V			V								
Bus Connections	O			O								
Bushings	I			I, C								
Cable Terminations	O			I	O	O	O	O	O	O	O	O
Capacitor	I			I, T								T, R
Control and Timing Relays	V			V		T		T		T		T, R
Controller and Multifunction Meter	V			V		T		T		T		T, R
Corrosion / Condensation	I			I, P								
CT Circuit	V			V				T				
Enclosure	I, S, P			I, P				S				S
Fans	V		I, V	I, V				T				R
Fuses	T			F								R
Ground Switch	V			I	V	V	V	V	V	V	V	V
Insect Screens	I, C			I	C	C	C	C	C	C	C	C
Insulators and Supports	I, C			I, C								
Kirk Key Interlocks	V			I	L	L	L	L, V	L	L	L	L, V
Main Switch	V			I	V	V	V	V	V	V	V	V
Power and Control Cables	I			I				T				T
Reactor	I			I, C				T				T
Space Heater Circuit	V			I, V				T				T
Thermostat	V			V				T				T
Vacuum Switches/Contactors	V			I, V				T				T, R

Note: Perform inspection and maintenance service per above schedule and record service dates.

Limited warranty policy

Medium voltage power capacitor products

Eaton warrants its MV Autovar Series products to be free from defects in materials and workmanship; Eaton's obligations under this warranty are limited to repairing or replacing any products which shall, within TWELVE (12) months after delivery to the original purchaser, however, be proved by our examination to be defective and which are returned to us, provided, however, that such return has been authorized by us and that the purchaser shall have inspected products received and notified us of any apparent defects discovered within thirty (30) days of receipt of shipment. All products/components, except fuses, are subject to Eaton's standard one year warranty from date of shipment.

This warranty does not extend to any of our products which fail to operate by reason of method of installation, application, or inspection, or have been subject to misuse, neglect, or accident, or have been repaired or substantially altered outside of our factory. Specifically, this warranty is limited only to those products installed according to Eaton's factory instructions and The National Electric Code within accepted journeyman's practice. This warranty does not extend to fuses. Also, this warranty does not extend to capacitor failure due to harmonic distortion or due to capacitor installation in environments other than those for which each product has been designed. THIS WARRANTY AND OBLIGATION THEREUNDER IS IN LIEU OF ALL OTHER WARRANTIES INCLUDING ANY STATUTORY WARRANTIES OF FITNESS OR MERCHANTABILITY.

Eaton shall not be liable on any claim of any kind, regardless of the theory of recovery employed, including negligence, lack of delivery, breach of warranty and strict liability, for any loss or damage resulting from, arising out of or in connection with this sale, or from the performance or breach of any terms thereof, or from the manufacture, sale, delivery, resale, repair or use of any product covered by or furnished under this contract which is beyond the remedies provided herein and such remedies shall be the sole and exclusive remedies. In no event shall we be liable for incidental, special or consequential damages.

Warranty terms are per Eaton Selling Policy 25-000.

This instruction manual is published solely for information purposes and should not be considered all-inclusive. If further information is required, you should consult an authorized Eaton sales representative.

The sale of the product shown in this literature is subject to the terms and conditions outlined in appropriate Eaton selling policies or other contractual agreement between the parties. This literature is not intended to and does not enlarge or add to any such contract. The sole source governing the rights and remedies of any purchaser of this equipment is the contract between the purchaser and Eaton.

NO WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, OR WARRANTIES ARISING FROM COURSE OF DEALING OR USAGE OF TRADE, ARE MADE REGARDING THE INFORMATION, RECOMMENDATIONS, AND DESCRIPTIONS CONTAINED HEREIN. In no event will Eaton be responsible to the purchaser or user in contract, in tort (including negligence), strict liability or otherwise for any special, indirect, incidental or consequential damage or loss whatsoever, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the information, recommendations and description contained herein.

Notes

Notes

Instruction Booklet IB158008EN
Effective December 2015

AutoVAR medium voltage automatic power factor correction capacitor banks commissioning, operations, and maintenance manual

For technical support and application engineering assistance, please contact Eaton's TRC at
1-800-809-2772 option 4, option 2
or email **pfc@eaton.com**

Eaton
1000 Eaton Boulevard
Cleveland, OH 44122
United States
Eaton.com

Printed in USA
Publication No. IB158008EN / Z17437
December 2015

Powering Business Worldwide