

Fuseless block banks installation instructions



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Powering Business Worldwide

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Safety for life



Eaton's Cooper Power series products meet or exceed all applicable industry standards relating to product safety. We actively promote safe practices in the use and maintenance of our products through our service literature, instructional training programs, and the continuous efforts of all Eaton employees involved in product design, manufacture, marketing and service.

We strongly urge that you always follow all locally approved safety procedures and safety instructions when working around high-voltage lines and equipment and support our "Safety For Life" mission.

Safety information

The instructions in this manual are not intended as a substitute for proper training or adequate experience in the safe operation of the equipment described. Only competent technicians, who are familiar with this equipment should install, operate and service it.

A competent technician has these qualifications:

- Is thoroughly familiar with these instructions.
- Is trained in industry-accepted high- and low-voltage safe operating practices and procedures.
- Is trained and authorized to energize, de-energize, clear, and ground power distribution equipment.
- Is trained in the care and use of protective equipment such as flash clothing, safety glasses, face shield, hard hat, rubber gloves, hotstick, etc.

Following is important safety information. For safe installation and operation of this equipment, be sure to read and understand all cautions and warnings.

Hazard Statement Definitions

This manual may contain four types of hazard statements:

DANGER

Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

CAUTION

Indicates a hazardous situation which, if not avoided, could result in equipment damage only.

Safety instructions

Following are general caution and warning statements that apply to this equipment. Additional statements, related to specific tasks and procedures, are located throughout the manual.

DANGER

Hazardous voltage. Contact with high voltage will cause death or severe personal injury. Follow all locally approved safety procedures when working around high- and low-voltage lines and equipment.

WARNING

Before installing, operating, maintaining, or testing this equipment, carefully read and understand the contents of this manual. Improper operation, handling or maintenance can result in death, severe personal injury, and equipment damage.

WARNING

This equipment is not intended to protect human life. Follow all locally approved procedures and safety practices when installing or operating this equipment. Failure to comply may result in death, severe personal injury and equipment damage.

WARNING

Power distribution and transmission equipment must be properly selected for the intended application. It must be installed and serviced by competent personnel who have been trained and understand proper safety procedures. These instructions are written for such personnel and are not a substitute for adequate training and experience in safety procedures. Failure to properly select, install or maintain power distribution and transmission equipment can result in death, severe personal injury, and equipment damage.

Fuseless block banks installation instructions

Product information

Introduction

Service Information MN230006EN covers instructions for the installation of capacitor blocks on substation banks. (The single-phase capacitors in these assemblies are furnished in hermetically sealed cases containing pack assemblies impregnated with a dielectric fluid; refer to MN230002EN for installation, maintenance, and field-testing instructions of individual capacitors.) Where applicable, the requirements of national and/or local codes and insurance underwriters must be followed.

Read this manual first

Read and understand the contents of this manual and follow all locally approved procedures and safety practices before connecting or operating this equipment.

Additional information

These instructions cannot cover all details or variations in the equipment, procedures, or process described nor provide directions for meeting every possible contingency during installation, operation, or maintenance. For additional information, contact your representative.



Figure 1. Fuseless capacitor bank

Acceptance and initial inspection

Fuseless capacitor blocks and their associated equipment are shipped on pallets, in open or closed crates or in containers.

Upon receipt, carefully inspect all equipment for damage or loss. If any discrepancies are revealed, immediately file a claim against the transportation agency and notify Eaton.

Use the factory bills of material and construction drawings to verify receipt of all equipment. The inspection should include the following items:

1. Inspect all insulators and bushings for cracks.
2. Verify all nameplate data to ensure the equipment is as ordered.

Handling and storage

If the capacitor equipment is to be stored for some time before installation, store to minimize the possibility of mechanical damage. In particular, protect the capacitor bushings and all porcelain.

Warranty

The performance of Eaton's Cooper Power series fuseless block banks is warranted for a period of one year from the date of shipment. Eaton will, at its option, correct, by repair or replacement, capacitor blocks or components which may fail because of defects in material or workmanship. The warranty is valid only if the equipment has been inspected completely upon receipt, installed properly, and has not been subjected to abnormal conditions. Such corrections shall constitute a fulfillment of all liabilities of Eaton. The company will not be liable for consequential damages or any expenses incurred in installation or transportation.

The proliferation of nonlinear loads in power systems has given rise to potential harmonic distortion problems when applying capacitors. When applying capacitor banks, a system study is recommended to determine if there will be any resonance between the capacitors and the system that may accentuate existing harmonics. Eaton can perform these studies.

Any other unusual/abnormal service conditions such as those listed in the Unusual Service Conditions section of these instructions, should be brought to the attention of Eaton. Modifications to the bank may require revision of the quoted price.

Instruction manual

Instruction manuals will be forwarded to you prior to the shipment of the equipment and a copy will be enclosed with the shipment. Thoroughly read and understand the instruction manual prior to movement, installation, operation and maintenance of the capacitor bank. The instruction manual will contain the following at a minimum:

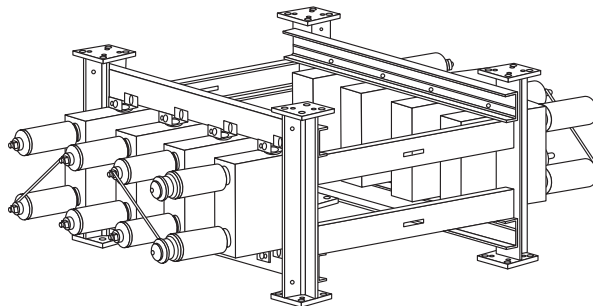


Figure 2. Fuseless block

1. Final Drawings
2. Bills of Materials
3. These Instructions
4. Drawings and Instructions for other Equipment supplied (as available).

Standards

ISO 9001 Certified Quality Management System

Safety precautions

WARNING

Hazardous voltage. Residual capacitive voltage may be present in the capacitor units after de-energizing. Follow the appropriate shorting procedure to discharge any residual voltage. Failure to comply can cause serious injury or death.

DANGER

Hazardous voltage. Explosion hazard. Do not energize a capacitor unit that has been shorted terminal-to-terminal or that has bulged or otherwise damaged tank. Failure to comply will result in death or severe personal injury.

1. Lift all blocks with the supplied lifting lugs. Lift all other parts by structural members only in accordance with their respective instructions, if applicable. Do not lift any equipment by the bushings or insulators unless directed by its instructions, if applicable.
2. DO NOT climb on insulators, bushings or capacitor units. Do not lift capacitors by their bushings or use the bushings to support human weight. Broken bushings may have sharp edges that can result in personal injury.
3. DO NOT ground a capacitor bank immediately after the bank has been disconnected from the system. For capacitor banks with units containing discharge resistors designed to discharge the capacitor unit from peak rated voltage to less than 50 V in 5 minutes, allow five minutes before grounding. For capacitor banks with units containing discharge resistors designed to discharge the capacitor unit from peak rated voltage to less than 75 V in 10 minutes, allow ten minutes before grounding. In the absence of design information, wait ten minutes before grounding.
4. Ground all parts after de-energization and before touching frames or terminals. Ground the neutral of ungrounded capacitor banks.
5. Before handling, short circuit the terminals of all capacitor units.
6. For capacitor banks with units containing discharge resistors designed to discharge the capacitor unit from peak rated voltage to less than 50 V in five (5) minutes, wait at least five (5) minutes before re-energizing the bank after it has been disconnected from the system. For capacitor banks with units containing discharge resistors designed to discharge the capacitor unit from peak rated voltage to less than 75 V in ten (10) minutes, wait at least ten (10) minutes before re-energizing the bank after it has been disconnected from the system. These times may be reduced with consultation of the factory.
7. DO NOT energize a capacitor unit that has been shorted terminal-to-terminal or that has a bulged or otherwise damaged tank.
8. Use all precautions for capacitor equipment in the same manner as listed under the utilities regulations for high tension equipment.

Fuseless capacitor banks

Each phase of a fuseless capacitor bank is constructed of one or more strings of series-connected capacitor units. Each string is typically connected between phase and neutral or phase and ground or differing phases. The individual capacitor units are not fused hence the name "Fuseless Capacitor Bank". Figure 3 is a schematic of a typical fuseless capacitor bank composed of two strings per phase. Each phase is contained in two blocks.

Each capacitor unit is constructed internally of smaller capacitors called elements or packs. These elements are constructed of aluminum foil electrodes and a dielectric of polypropylene film. The elements are arranged in a series and parallel combination (Figure 4) to achieve the voltage and kvar rating of the unit. There are many of these "series sections" or "internal series groups" in a string of capacitors. Figure 5 is a schematic of a typical string showing the individual series sections.

When the polypropylene dielectric of an element fails, the energy stored in the parallel connected capacitance discharges into the failure point puncturing many layers of film and foil. The small arc causes the film layers to recede allowing many layers of the aluminum foil electrodes to touch and weld together forming an electrical joint. This electrical joint is very stable and exhibits very low losses. This stable joint is capable of carrying the full capacitor unit current and the typical transient currents. The series section containing the failed element is now completely "shorted out". A capacitor unit containing a "shorted out" series section may remain in service indefinitely.

Because there are many of these series sections in the string, the overvoltage on the remaining series sections resulting from the "shorting out" of one series section failure will be small. Typically, the unbalance relaying scheme will be set-up to remove the capacitor bank from service when the overvoltage on the remaining series sections exceeds their continuous rating.

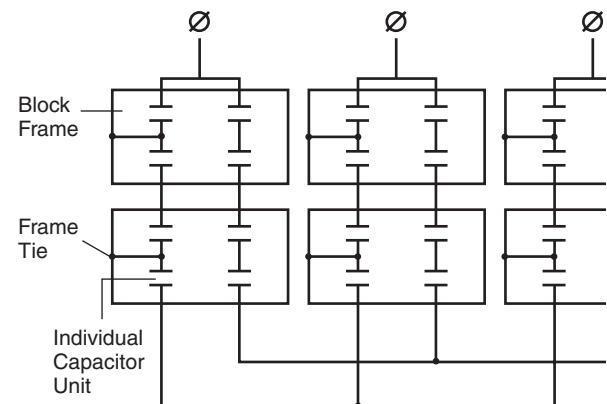


Figure 3. Typical fuseless capacitor bank schematic

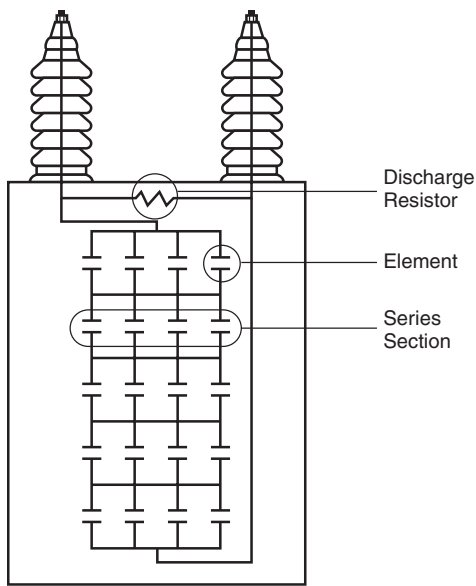


Figure 4. Capacitor unit

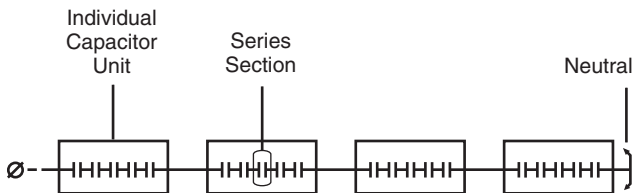


Figure 5. String of capacitors

Equipment description

Fuseless capacitor blocks (Figures 1 and 2) are suitable for indoor or outdoor installation. The bank will consist of one or more blocks of capacitors. The block frames and other structure may be constructed of marine grade structural aluminum or galvanized steel.

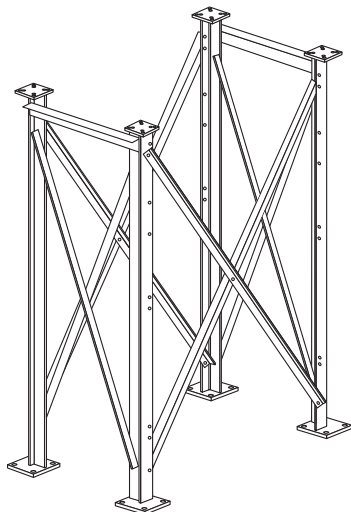


Figure 6. Typical elevating structure

Installation instructions

Fuseless capacitor banks may be suitable for both indoor and outdoor installation depending on the accessories. The blocks can be mounted on platforms, elevating structures (Figure 6) or directly to the foundation. The stacking of the fuseless capacitor blocks may require base and/or stacking insulators. Base insulators isolate the blocks from the platform, elevating structure or foundation. Stacking insulators are used to provide electrical insulation between block frames at different potentials. When base insulators will be directly mounted to a concrete foundation, adapters may be required.

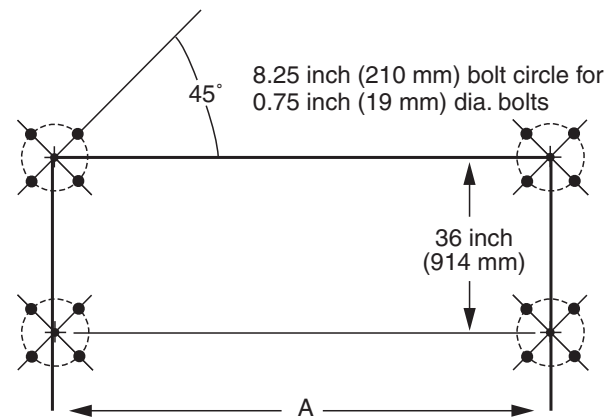


Figure 7. Typical anchor bolt plan

Anchor bolt plans (Figure 7) and static foundation loading are furnished with the capacitor bank assembly drawings. The design of all concrete footings and foundations are dependent on the soil conditions at the installation site and are thus the responsibility of the customer. Anchor bolts are selected and furnished by the customer.

Field assembly drawings

Field assembly drawings are supplied with the instruction manual. Prior to installation, study the assembly drawings to develop a plan for assembly.

Moving capacitor equipment

When the capacitor block is to be moved, it must be lifted using the lifting lugs provided. The lifting lugs are designed to support the weight of only one block. Do not lift multiple blocks simultaneously. Using lifting points other than those provided may result in damage to the block frame and/or the installed capacitor units. Do not attempt to slide or skid the block. Lifting speed must be smooth and constant to avoid impulse loading.

Lift all other parts by structural members only in accordance with their respective instructions, if applicable. Do not lift any equipment by the bushings or insulators unless directed by its instructions, if applicable.

Erection of elevating structure

An elevating structure (Figure 6) may be supplied to raise the capacitor equipment above the foundation for equipment protection and personnel safety. The bottom plates of the elevating structure has holes for anchoring to the foundation. The top plates have holes for the mounting of a capacitor block or station post insulators.

The elevating structure is shipped unassembled from the factory. Components typically include two welded end sections, two sets of cross braces and the necessary hardware. To assemble:

1. Set the two welded end sections over the anchor bolts in the foundation and secure with lock washers and nuts.
2. Tie the cross braces with two nuts and bolts at each end section and one nut and bolt in the middle at the point of brace cross-over. A spacer is used at the point of brace cross-over for proper geometry.

Framework for the support of equipment such as switches, arresters, reactors, insulators and conductors may be supplied for attachment to the elevating structure.

Position of blocks

Care must be taken to place the blocks in the bank in accordance with the outline drawings. When necessary, to establish block frame potential, one string in the frame will be electrically connected to the frame. The frame ties are shown in the outline drawings. The nameplates of each block must all be on the same end for correct operation.

Bank erection

If used, the base and stacking insulators should be bolted in place with their hardware loose for adjustment. Slowly lower the block to its mounting position avoiding impact. Use flat and lock washers on all bolts used to assemble the blocks to each other or their base.

Electrical connections

The conductor used to connect the capacitor bank to the system should have a continuous current rating of at least 35 percent more than the nominal current rating of the bank.

The assembly of all electrical connections is of vital importance to the proper operation of the capacitor bank. All connections should be made in accordance with the instruction manual. It is highly recommended that the torque of all electrical connections be checked at least 24 hours after the initial torque. This allows for some plastic

deformation of the metal of the base conductor, connectors and hardware. If supplied, the top piece of the bird guard that covers each capacitor terminal is shipped separately. This allows for a check of the capacitor terminal hardware during assembly. The top piece of the bird guard should be snapped in place after checking each terminal connection.

Grounding

If supplied, one leg of each elevating structure end section is supplied with a two-hole NEMA pad. Connect a suitable size conductor from the two-hole NEMA pad to the ground. Base adapters should be grounded with a conductor attached between the anchor bolt nut and the adapter.

Series reactors

Series reactors may be supplied for current-limiting and/or tuning of the bank. Reactors connected in series with the capacitor bank should have a continuous current rating of at least 35 percent more than the nominal current rating of the bank. This requirement may be relaxed for highly tuned capacitor/reactor combinations where the currents are more predictable.

When applying a series reactor, care must be taken to ensure proper clearance between the reactor and metallic objects or sensitive electronic equipment. If the reactor is supplied with the capacitor bank, the outline drawing will have the reactors placed for proper clearance with all other equipment in the drawing. Consult the reactor drawings in the instruction manual for the required clearance to other equipment.

Surge arresters

It is recommended that capacitor banks be protected against overvoltages due to lightning or switching surges with surge arresters. To protect the capacitor bank from the high overvoltages associated with a switch restrike, the arresters should be applied between the switching device and the capacitor bank and as close to the capacitor bank as possible.

Care must be taken to ensure that the energy rating of the arresters is adequate for application at a capacitor bank. For switched capacitor banks, the highest energy condition arresters are likely to see is the restrike of the capacitor bank switch when de-energizing the bank. It is recommended to size the arresters for the energy associated with a single restrike of the switch.

Capacitor switching

Capacitive currents

The capacitor bank switching device should have a continuous current rating of at least 35 percent more than the nominal current rating of the bank. The switching device should be capable of energizing and de-energizing the bank at maximum system voltage, with the maximum harmonic distortion of the bank current and with the bank neutral grounded or ungrounded as applicable.

Grounded wye capacitor banks subject the capacitor bank switching device to a 2 per unit recovery voltage. Ungrounded wye capacitor banks subject the capacitor bank switching device to recovery voltages higher than 2 per unit and as high as 4.1 per unit. The voltage rise across series connected tuning reactors result in higher recovery voltages than encountered when switching banks without series connected reactors.

Capacitor switching devices not rated for capacitor switching may restrike resulting in high system voltage surges that can damage the capacitor bank, arresters and other equipment.

Inrush and outrush currents

When the capacitor bank switch is closed, a high-frequency, high-magnitude current flows into the bank attempting to equalize the system and capacitor voltages. If the bank is isolated from other banks, the inrush current is limited by the inductance of the source and the capacitance of the bank. Typical values for this inrush current are 5 to 20 times the nominal bank current at frequencies of several hundreds of hertz.

If two or more capacitor banks are connected on the same bus, very high magnitude and frequency currents are possible. Only the impedances of the banks and the circuit limit the current.

Current outrush from a capacitor bank may also be a concern if a fault develops or a breaker closes into a fault.

Eaton's Cooper Power series capacitor banks will satisfactorily withstand these high magnitude and high frequency currents. However, other equipment such as the unbalance relaying equipment, capacitor bank switching device and other switching devices in the substation may not withstand these currents. It is recommended that the factory be consulted when the banks will be switched back-to-back or anytime there is doubt regarding the magnitude and frequency of the currents, or the suitability of the installation.

Protective relaying

The purpose of capacitor bank protective relaying is to increase the availability of the capacitor bank by warning personnel of problems in the bank and removing the bank from service before severe damage occurs. The design of the protective relaying begins with bank design.

Unbalance relaying

In practice, the unbalance detected by the unbalance detection scheme is comprised of the following types of unbalance:

1. Inherent Unbalance
2. System Unbalance
3. Unbalance due to series section failures

The inherent unbalance is that due to the manufacturing tolerances of the capacitor units. The system unbalance is that due to system phase voltage unbalance.

The sensitivity necessary to detect individual series section failures requires an unbalance detection scheme that is not sensitive to system unbalance and can be adjusted to compensate for the capacitor bank inherent unbalance. Small fuseless capacitor banks may not need to compensate for capacitor bank inherent unbalance.

While rare, the two failure modes of most concern in a fuseless bank are the unit major insulation failure and the flashover of a unit bushing. Because the units have no external fuse, the only protection in the event of a capacitor unit major insulation failure or a bushing flash-over is prompt relaying to remove the bank from service before the damage spreads.

The unbalance protective relaying schemes used with fuseless banks will compensate for system unbalance, and thus are not required to coordinate with the clearing of a line to ground fault. Also, as the bank has no fuses, the unbalance protective relaying scheme is not required to coordinate with the operation time of an external fuse. Given this and the necessity for short delay times, the trip time delay should be set very short. A trip time delay of 0.5 seconds or less is recommended. However, an instantaneous delay setting should not be used to avoid possible unwanted operations.

To aid in the setting of customer supplied unbalance relaying equipment and purchasing replacement capacitor units, the nameplates of the capacitor units supplied in the fuseless capacitor bank will contain the number of series sections contained within the unit. If the unbalance relaying equipment is supplied with the capacitor bank, the instruction manual will contain information for the setting of the relay.

Overcurrent protection

Power fuses or switches with protective relaying should be applied for protection against major faults within the capacitor bank. If switches with protective relaying are supplied with the capacitor bank, the instruction manual will contain information for the setting of the relay.

Initial inspection and testing

The entire bank should be carefully inspected prior to initial energization. Included in the initial inspection should be a check of the following points:

1. Ensure that all equipment supplied has nameplates matching those shown on construction drawings.
2. Inspect all electrical connections to see that they are installed in the correct locations per the construction drawings and are tightened to a torque of 16 - 19 foot-pounds (21 - 26 newton-meters) for good electrical contact.
3. If bird guard material is supplied, attach the top piece of each capacitor terminal bird guard to its base. The top piece has been shipped separately.
4. Verify the mechanical assembly of the bank is in accordance with the outline drawings and is sound.
5. Verify electrical clearances around and within the bank.
6. Record the capacitance of each string in the bank with a low voltage meter calibrated to the National Institute of Standards and Technology (NIST) or equivalent agency that develops and promotes measurement standards. Also, record the ambient temperature at the time of the measurement. This information may then be compared to the production test reports for consistency. This will aid in the location of a defective unit during maintenance. See the section on locating a defective capacitor unit for the measuring procedure.
7. Ensure that the insulators are installed right-side up. Wipe clean all insulators and bushings. Visually inspect for damage such as chips and cracks. Dirty insulators and bushings may cause flashover and damage to the equipment.
8. Visually inspect all capacitor units for damaged tanks and leaks.
9. Verify settings of all protective relaying and ensure it is activated.
10. Test operate all load-break, disconnect, and grounding switches and secondary accessory equipment.
11. Ensure bank is properly grounded to station ground per utility grounding practices.
12. Just prior to energization, open all grounding and shorting switches and ensure all grounding and shorting tackle is removed.
13. All secondary wiring should be confirmed during commissioning of the protection system.
14. Perform a thermal scan of all electrical connections after a minimum of two (2) hours of continuous energization to check for overheated electrical joints. Pay particular attention to the capacitor terminal temperatures.

Initial energization

Immediately after initial energization, perform the following:

1. Verify that the voltage rise is as expected and that the bank voltage and currents are within its ratings. The phase currents should be approximately equal.
2. Check the level of unbalance at the unbalance detection relay. A small inherent unbalance may be nulled if the relay has such capability. An unbalance alarm or an otherwise high level of unbalance, not attributable to inherent unbalance, likely means that there has been a dielectric failure.
3. Approximately 24 hours after the initial energization, recheck the level of unbalance and remove the bank from service for visual inspection. This inspection should include a check for signs of overheated electrical joints.

Operation

Unusual service conditions

Unusual service conditions may require special construction or operation and should be brought to the attention of the factory. Among such unusual service conditions are:

1. Operation at altitude above 6000 feet (1800 m).
2. Residual voltage at energization greater than 10% of rated voltage.
3. Exposure to damaging fumes or vapors, salt air, steam, excessive moisture or dripping water.
4. Exposure to explosive dust or gases.
5. Exposure to excessive, abrasive or conductive dust.
6. Exposure to severe weather conditions.
7. Exposure to abnormal vibration, shocks or tilting including earthquakes.
8. Unusual transportation or storage conditions.
9. Installation that prevents adequate ventilation.
10. Operation in ambient temperatures outside (above or below) the rating of the equipment.
11. Voltage stress on the insulation and dielectric outside the continuous and momentary ratings.
12. Operation at frequencies other than the rated frequency.
13. Unusual wave form distortion or harmonics causing excessive kvar loading or voltages.
14. Back-to-back switching.
15. Any other unusual or special operating requirements.

Fuseless block banks installation instructions

Overvoltage operation

The capacitors are designed for continuous contingency operation at 110% of rated voltage. Operation of the capacitor bank at voltages above 110% of rated voltage for extended periods of time will shorten the life of the capacitors and should be permitted only in emergency conditions.

These overvoltages are permissible since a safety factor is provided in the design of the capacitors. Consideration should also be given for the possible overvoltage operation due to the failure of series sections within the bank.

The magnitude of overvoltage that can be tolerated without loss of capacitor life is dependent upon the number and duration of the applied overvoltage. The values shown in Table 1 are based on full life expectancy, with overvoltages occurring a maximum of 300 times during the life of the capacitor. For operation at overvoltages beyond those shown in Table 1, consult your Eaton's Cooper Power series product representative.

Table 1. Overvoltage operations

Duration	Times rated voltage ¹
6 cycles	2.20
15 cycles	2.00
1 second	1.70
15 seconds	1.40
1 minute	1.30
30 minutes	1.25
30 minutes every 24 hours	1.15 ²

1 Multiplying factors apply to rms rated voltage. Crest voltage must not exceed rms by more than $\sqrt{2}$.

2 There is no limit to the number of overvoltages during the life of the capacitor unit.

Undervoltage operation

The bank may be operated at voltages which are less than the capacitor voltage ratings. However, full kVAR output varies in direct proportion with the square of the ratio of the applied voltage to the rated voltage.

De-Rating

Capacitor banks may be de-rated by removing or isolating capacitor units from service. Fuseless capacitor banks can be reconfigured by removing or isolating capacitor strings in equal numbers from each section of each phase. When reconfiguring a fuseless capacitor bank to a lower Mvar rating perform the following:

1. Remove the capacitor bank from service and install safety grounds following the locally approved procedures and safety practices.
2. On the string to be removed from service, remove the leads connecting the string to the phase bus and the neutral collector bus (that is, the two ends of the string).

3. On the string to be removed from service, remove all the leads between capacitors mounted on different blocks.
4. Always assure that the string with the frame tie (Figure 3 on page 4) remains in the circuit. If a string used to energize the frame is to be disconnected then another string on that same phase and block must be utilized as the frame tie. The new tie connection should have the same voltage as the original tie connection.
5. Make sure that only one string is used for the block tie and that every block has only one tie connection.
6. If the capacitor units of the disconnected strings are left on the bank, verify that all the units in the disconnected string (spare string) are shorted and connected individually to the block. Also verify that the jumpers in the spare string that connect the capacitors between blocks are removed.
7. Check and adjust the protection settings as required, based on the new de-rated configuration.

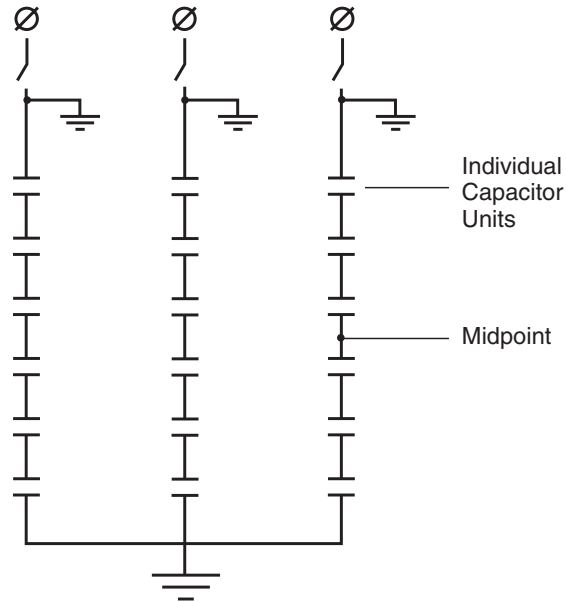


Figure 8. Grounded capacitor bank



Hazardous voltage. Contact with high voltage will cause death or severe personal injury. Follow all locally approved safety procedures when working around high- and low-voltage lines and equipment.

Inspection and maintenance

Routine maintenance

Eaton's Cooper Power series fuseless capacitor banks require very little maintenance. Periodic maintenance should include the following:

1. Visual examination of the bank looking for foreign matter and damaged or excessively dirty insulators.
2. Visual examination of all capacitor units for damaged or excessively dirty bushings, leakage or unusual swelling.
3. Visually examine all electrical connection for signs of overheating. Perform a thermal scan of all electrical connections after a minimum of two (2) hours of continuous energization to check for overheated electrical joints. Pay particular attention to the capacitor terminal temperatures.
4. Examine all metal parts for signs of corrosion.
5. Verification of the protective relay settings. At longer maintenance intervals, the protective relaying should be tested.
6. Check the level of unbalance at the unbalance detection relay.

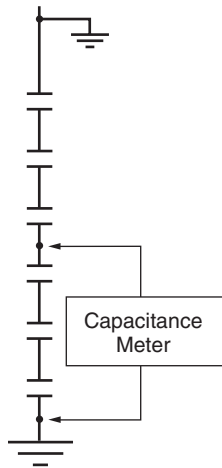


Figure 9. Midpoint-to-Ground Measurement

WARNING

Hazardous voltage. This procedure must only be performed on a capacitor bank or unit that has been removed from service. Failure to comply can result in serious injury or death.

Locating a defective capacitor unit

Locating a defective capacitor unit in a fuseless capacitor bank requires some capacitance measurements but is relatively easy.

The failure of an element in the all-film capacitor results in the shorting of an entire series section causing the

capacitance of the unit to increase. The first step is to locate the string with the defective unit and then the unit itself. The following procedure should be used:

1. Ground the incoming phases and the neutral as shown in Figure 8. (See **Safety precautions** section on page 2.)
2. Measure the capacitance of each string from its midpoint to ground (Figure 9). If the strings have an odd number of capacitor units measure from one bushing of the middle unit to ground. Compare the measured value with the values recorded earlier. The string with the defective capacitor unit will have an increased capacitance. If the capacitor unit terminals have the Nature Guard terminal covers, the tops of the covers are easily removed and replaced to effect the measurement. The string with the frame tie may have capacitance readings that are significantly different than those measured earlier or during production. If this is the case disconnect the frame tie and repeat the measurement. Remember to reconnect the frame tie when finished.
3. Once the string with the defective unit is identified, the defective unit is easily located by measuring the capacitance of the units in the string.

Ordering replacement capacitor units

Replacement capacitor units should be rated for application in the particular fuseless capacitor bank. It must be an all-film design having the same kvar and voltage of the unit it is replacing. The BIL of the replacement unit must be greater than or equal to the unit it is replacing. Also, if the bank is subject to the high frequency and high magnitude inrush currents of back-to-back switching, the manufacturer of the replacement capacitor should be notified. It is also recommended that the replacement capacitor unit to have the same number of series sections as the unit it is replacing for ease of unbalance relay setting.

WARNING

Hazardous voltage. This procedure must only be performed on a capacitor bank or unit that has been removed from service. Failure to comply can result in serious injury or death.

Field testing

Periodic testing of capacitors as a preventative maintenance function is not recommended. Occasionally, it is necessary to field test capacitors to determine if any damage or failure has occurred. This is particularly important if the capacitors have been subjected to unusual service conditions or if a number of series sections have recently failed at a capacitor installation.

Checking the capacitance of a unit is the best way to determine whether or not the capacitor is partially failed. High voltage insulation strength tests may be used in an effort to identify capacitors which would fail in the near future if they were re-energized. The results of this type of testing and the problems related to high-voltage testing in the field indicate that the value of this type of test is somewhat limited.

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Publication No. MN230006EN REV01
November 2016

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