

Surge capacitors or capacitors included as a component part of other apparatus and conforming with the requirements of such apparatus are excluded from these requirements.

460.3 Enclosing and Guarding.

(A) Containing More Than 11 L (3 gal) of Flammable Liquid.

Capacitors containing more than 11 L (3 gal) of flammable liquid shall be enclosed in vaults or outdoor fenced enclosures complying with Article 110, Part III. This limit shall apply to any single unit in an installation of capacitors.

(B) Accidental Contact. Where capacitors are accessible to unauthorized and unqualified persons, they shall be enclosed, located, or guarded so that persons cannot come into accidental contact or bring conducting materials into accidental contact with exposed energized parts, terminals, or buses associated with them. However, no additional guarding is required for enclosures accessible only to authorized and qualified persons.

Part II. 1000 Volts, Nominal, or Less

460.6 Discharge of Stored Energy. Capacitors shall be provided with a means of discharging stored energy.

(A) Time of Discharge. The residual voltage of a capacitor shall be reduced to 50 volts, nominal, or less within 1 minute after the capacitor is disconnected from the source of supply.

(B) Means of Discharge. The discharge circuit shall be either permanently connected to the terminals of the capacitor or capacitor bank or provided with automatic means of connecting it to the terminals of the capacitor bank on removal of voltage from the line. Manual means of switching or connecting the discharge circuit shall not be used.

460.8 Conductors.

(A) Ampacity. The ampacity of capacitor circuit conductors shall not be less than 135 percent of the rated current of the capacitor. The ampacity of conductors that connect a capacitor to the terminals of a motor or to motor circuit conductors shall not be less than one-third the ampacity of the motor circuit conductors and in no case less than 135 percent of the rated current of the capacitor.

Capacitors are rated in reactive kilovolt-amperes (kilovars or kVAR) or kilovolt-amperes capacitive (kVAc). Both ratings are synonymous. The kVAR rating shows how many reactive kilovolt-amperes the capacitor will supply to cancel out the reactive kilovolt-amperes caused by inductance. For example, a 20-kVAR capacitor will cancel out 20 kVAR of inductive reactive kilovolt-amperes.

The capacitor circuit conductors and disconnecting means must have an ampacity not less than 135 percent of the rated current of the capacitor. Capacitors are manufactured with a tolerance of zero percent to 15 percent, so a 100-kVAR capacitor can draw a current equivalent to that of a 115-kVAR capacitor. In addition, the current draw varies directly with the line voltage, and

any variation in the line voltage from a pure sine wave form causes the capacitor to draw an increased current. Considering these factors, the increased current can amount to 135 percent of the rated current of the capacitor.

The current corresponding to the kVAR rating of a 3-phase capacitor, i_c , is computed from the following formula:

$$i_c = \frac{\text{kVAR} \times 1000}{\sqrt{3} \times V}$$

The ampacity of the conductors and the disconnecting device is then determined by multiplying i_c by 1.35.

Where harmonic-producing loads are present, adding capacitors to the electrical system can place the system in a harmonic resonance condition. The harmonic loads can excite the electrical system at the harmonic resonance frequency and cause overcurrent and overvoltage conditions. If capacitors are to be placed on electrical systems with harmonic loads, an engineering study should be conducted that evaluates the size and placement of capacitors and the reactive impedance and load of the system. Capacitors may need a reactor placed in series with them to help detune the electrical system from a harmonic resonance condition.

(B) Overcurrent Protection. An overcurrent device shall be provided in each ungrounded conductor for each capacitor bank. The rating or setting of the overcurrent device shall be as low as practicable.

Exception: A separate overcurrent device shall not be required for a capacitor connected on the load side of a motor overload protective device.

Unless the exception applies, the overcurrent device must be separate from the overcurrent device protecting any other equipment or conductor. See Exhibit 460.1, diagrams (a) and (b).

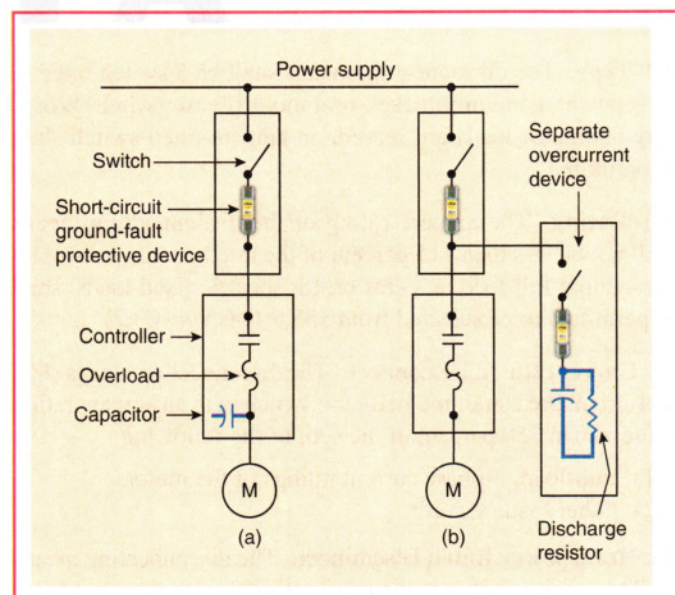


EXHIBIT 460.1 Methods of connecting capacitors in induction motor circuit for power factor correction.