

**SECTION 16480**  
**MOTORS CONTROLLERS AND POWER FACTOR CORRECTION**

A. Motor Controller Applications

1. Motor control centers shall be utilized whenever there are four (4) or more motors loads. Utilize individual motor controllers for less than four (4) motor loads. Do not install VFDs in motor control centers.
2. Preferred manufacturers for motor controllers are Allen-Bradley, Cutler-Hammer, General Electric, Siemens, and Square D.

B. Individual Motor Controllers (3 Phase)

1. Individual 3 phase motor controllers shall be combination type with fusible disconnects. The controllers shall have the following features:
  - a. Individual control transformer with fused primary and secondary, 120 volt secondary output, and 50VA spare capacity.
  - b. Manual reset overloads.
  - c. Hand-Off-Auto selector switch unless noted otherwise.
  - d. Long life neon or LED pilot lights to indicate unit is in the run condition. Where multi-speed motors are served provide separate pilot lights for each speed.
  - e. Phase reversal/phase loss relays.
  - f. NEMA Size "0" minimum.
  - g. NEMA rated contacts--IEC are not acceptable.
  - h. Two (2) auxiliary contacts convertible from N.O. to N.C.
  - i. NEMA rated enclosure for the environment present, usually NEMA 1 for interiors and NEMA 3R for exteriors.
2. Controllers for motors 20 horsepower and smaller at 208 volts, and 50 horsepower and smaller at 480 volts, shall be full voltage non-reversing. Star-delta, closed transition, or solid state "soft-start," reduced voltage type controllers shall be used for motors 25 HP and larger at 208 volt, and 60 HP and larger at 480 volt.

### C. Individual Motor Controllers (Single Phase)

1. Single phase manual starters for fractional horsepower motors shall consist of a quick make, quick break, toggle switch with one piece melting alloy type thermal overloads. Where applicable, pilot lights shall be long life neon.
2. Where fractional horsepower motors are to be automatically started, use starters meeting the requirements of the paragraph above.

### D. Motor Control Centers

#### 1. General

- a. Bus bar shall be copper and a separate ground bus shall be included throughout.
- b. Wiring shall be NEMA Class 1, Type B-T.
- c. Enclosure shall be NEMA 1 gasketed for interior and NEMA 3R gasketed for exterior installations. Units shall be floor mounted.
- d. Provisions for future addition of sections shall be included so that matching sections of the same current rating can be added without the use of transition sections.
- e. Adequate horizontal and vertical wireways shall be provided. In general 12" at top, 6" at bottom, and 6" vertical shall be specified.
- f. The main horizontal bus shall be enclosed in an isolated compartment to prevent accidental contact with other equipment or wiring. Compartment shall have removable barriers to permit access for maintenance purposes.
- g. Minimum starter size shall be NEMA 1. Starters shall meet the requirements of paragraph B on previous page. (3Ø starters shall have 3" min. cubicle extension for control relays)
- h. All cover doors (front and rear) shall be hinged type. Where adequate space for motor control centers is a problem consideration may be given to back-to-back construction.
- i. Minimum gauge steel used on doors shall be #14.
- j. Care should be used in locating the MCC. At minimum the location should meet NEC requirements of Table 110.26(A)(1) for a Type 2 condition. The exclusively dedicated space requirements of NEC Article 110.26(F) shall be strictly enforced. Additional space for maintenance, future extensions, and possible replacement should be factored into the location selected. The

consultant shall work with the Engineering Services or CFS in locating this equipment.

- k. Where motor control centers are rated 600 amps or greater provide with a main disconnect. Disconnect may be a molded case circuit breaker.
- l. Each motor control center shall have a minimum of two (2) spare cubicles fully equipped for a future motor load and two (2) spaces for future starters.

## 2. Fault Withstand Capability

- a. The motor control center shall be suitable for operation at the maximum available fault current. The unit shall be labeled by the manufacturer to indicate the maximum fault current rating taking into account the structure, bussing, main feed, starter cubicles, and devices within the motor control center. Do not use bus bar bracing or rating of the main disconnect as the maximum available fault current rating for the motor control center.
- b. The consulting engineer shall specify the interrupting rating of the motor control center equipment.

## 3. Preferred Manufacturers

- a. Allen Bradley, "Center-Line"
- b. Cutler-Hammer, "2100 Line"
- c. GE, "8000 Line"
- d. Siemens, "Model 95"
- e. Square D, "Model 6".

## E. Variable Frequency Drive

### 1. General

Variable Frequency Drive (VFD) shall convert incoming three phase, 60 hertz power to an adjustable voltage and frequency for controlling motor speed. Speed range shall be from 10% to 110%. The variable frequency drive shall use full digital pulse width modulation using insulated gate bipolar transistors (IGBT) for speed control and shall include the following:

- a. Minimum efficiency at full load of 95 percent.
- b. Power Factor of 1.0 to .95 lagging over entire operating range
- c. Total harmonic voltage distortion shall not exceed 5% as measured on the line side of the drive input.
- d. Power outage ride through capability of 2 seconds with no disruption of output. This is to allow for operating times of utility system circuit breakers.

- e. Adjustable auto restart with selection of number of restart attempts and time interval between restarts.
- f. Ability to start (or restart) into a rotating motor without component failure or faulting of the drive. Drive shall employ "start on the fly" method.
- g. Integral fused switch on line side of drive for circuit disconnecting means.
- h. Where directed by Engineering Services or CFS, include manual by-pass feature with magnetic contactors.

## 2. Product Features

- a. Solid state circuit protection incorporating voltage rate-of-change and current rate-of-change protection for IGBTs.
- b. Instantaneous electric trip protection for the following occurrences:
  - 1) 110% of drive maximum sine wave current rating is exceeded.
  - 2) Output phase-to-phase short circuit condition and output phase-to-ground short circuit condition.
  - 3) High and low input voltage and loss of phase input current.
- c. LCD display, 2 line, 40 character minimum. Display shall indicate operating parameters with English descriptors.
- d. Keypad adjustment controls for the following shall be provided:
  - 1) Maximum (15 to 66 Hz) and minimum (3 to 60 Hz) frequency.
  - 2) Acceleration and deceleration times (1 to 360 seconds).
  - 3) Voltage/Hz ratio and voltage offset boost.
  - 4) Current limit (50% to 110%).
  - 5) Three critical frequency avoidance bands.
  - 6) Switching frequency adjustment (2 to 8 kHz, set to 3 kHz).
- e. In general, the control signal for the drive will be 4-20mA or a 0-10vfdc signal from a Digital System Controller in the building's temperature control system.

## 3. Installation

- a. Location of variable frequency drive shall be selected to allow for adequate clearances for service, maintenance, and replacement. Distance from load served shall be as short as practical and under no circumstances to exceed manufacturer's recommendations.
- b. Where specified, drive isolation transformers shall be located adjacent to the VFD. Secondary conductors shall not exceed 10'-0" without overcurrent

protection.

- c. Electrical noise shall not exceed IEEE Std. 519, with "Point of Common Coupling" defined as the line side of the isolation transformer and assuming the values for "General Systems" in chapter 10, "Recommended Practices for Individual Consumers".

4. Preferred manufacturers of variable frequency drives are Allen-Bradley, Asea Brown Boveri, and Danfoss Graham.

#### F. Power Factor Correction

1. Power factor correction capacitors shall be specified for motors 10 horsepower and larger which do not use a variable frequency drive.
2. Capacitors shall be connected to the motor controller on the load side of the contactor and ahead of the starter overloads. Locate capacitor adjacent to or above motor controller.
3. Capacitors shall utilize non-flammable, NFPA III B impregnant. Units shall have current limiting fuse in each phase and shall have blown fuse indicator pilot lights on front of enclosure.
4. Preferred manufacturers for power factor correction equipment are Aerovox, General Electric, Myron Zucker, Commonwealth Sprague, Square D Company, NEPSI (medium voltage only) and Controllix (medium voltage only).
5. Consultant shall evaluate harmonic loading of the system and specify filtered capacitors where required.