SECTION 16480

MOTOR CONTROLLERS

Part 1 -Design Directives

Motor starters, as far as practicable, shall be grouped together or part of a unitized motor control center and shall be NEMA rated combination type. The following factory installed options shall be included with each starter.

10 HP and larger shall include phase failure protection with phase angle sensing circuitry.

120-volt control transformer with primary fuses and the secondary bonded to the enclosure.

Cover mounted HAND-OFF-AUTO selector switch and LED pilot light. HOA selector switches controlling equipment that may be damaged by continuous operation, such as air compressors and sump pumps, shall be spring loaded to the OFF position from the HAND or TEST position.

Lockable motor starter disconnects shall serve as the disconnecting means for motors and equipment contained in the same room as the motor starter [ref NEC 430-102 and Exceptions]. Redundant motor disconnect switches shall only be installed where the motor is remote (in a different room) from the motor starter disconnect or required by code.

Motors over 3/4 HP shall be three phase.

Motors 1 HP and over shall be operated at 480 volts where a 480-volt supply is available.

Three phase motors operated on 208-volt systems shall be rated 200 volts.
System phase rotation shall be CCW (ABC).

Two speed motors shall not be used in other than fractional horsepower applications such as unit heaters. All other multi-speed applications shall employ variable speed drives.

Thermal overloads shall be of the bimetallic or melting alloy type. Solid-state thermal overloads are not permitted.

Class two wiring that provides connection to the energy management system shall not be installed inside motor control centers. The class one wiring of the motor control circuit to be operated from the energy management system shall be run to a dedicated enclosure housing the class two relay.

Spare fuses and internal storage space shall be supplied with all motor control centers

Part 2 -Products

Cutler Hammer
GE
Square D

Part 3 -Execution

All class two control wiring (DDC) shall enter the drive through a dedicated raceway system and shall be protected from contact with line voltage conductors by the application of a UL rated nylon “spiral wrap” cover over the entire length of the conductor inside the enclosure.

While in storage at the construction site the Motor Control Centers shall be protected against damage at all time. MCCs shall be stored in a dry environment with temperature and humidity controlled to within the ranges specified by the manufacturer. Space heaters shall be installed and energized when necessary to control humidity.

Drives shall be located so as to comply with all the requirement of the National Electrical code. Close attention shall be paid to the minimum clear workspace requirements of NEC article 110

The requirement for rigid conduit below eight feet in mechanical rooms is waived for motor control centers.

Variable Frequency Drives

Part 1 -Design Directives

A dedicated VFD shall be provided for each driven load. The use of a single VFD and an alternating circuit arrangement is not acceptable.

The inverter sections shall be configured as follows:

30 HP and larger drives shall be equipped with 12 pulse or greater inverter sections. (Note: 6 pulse units will be rejected.)

25 HP and less drives shall be equipped with 6 pulse or greater inverter sections.

All Drives shall be of the same manufacturer.

Input control signal compatible with automatic controls and/or building automation control system.

The size of the drive shall be coordinated with the driven equipment manufacturer. Motor nameplate currents shall be verified. The minimum full load output current of the drive shall be no less than the value stated in the National Electrical Code (NFPA-70) Article 430 tablefor Full Load Current, Three-Phase Alternating-Current Motors.

Part 2 -Products

Provide complete variable frequency drives with characteristics as described in this section and as shown on the drawings. Acceptable manufacturers as noted below:

1) ABB
2) Allen Bradley
3) Magnetek/Yaskawa

Each drive shall be mounted with all accessories in a single NEMA 1 enclosure.

Complete drawings shall be furnished and approved before proceeding with manufacture. Drawings shall consist of a specific bill of material, connection diagrams and suitable outline drawings showing details necessary to locate conduit stub-ups and field wiring.

The VFD shall comply with the latest applicable standards of ANSI, IEEE and NEMA

Unless waived in the request for quotation, the submittal shall include harmonic calculations made in accordance with IEEE 519-1992 showing that the specified total harmonic voltage and current limits are met. Calculations shall assume worst case system conditions and 50% transformer loading at the point of common coupling. System 1-line, 480V transformer data, standby generator data, and primary fault current data required to make these calculations is included in the system short circuit study and shall be obtained from Electrical Contractor. The submittal shall include the following information:

All input data and assumptions.

All calculations and computer printouts used in the analysis including input documentation.

All calculations shall be in accordance with IEEE 519 with all drives at 100% speed. The point of common coupling shall be the secondary connection of the transformer supplying that group of devices. These calculations shall be done with the transformer loaded to no more than 50% of its nominal capacity. These calculations shall also be done with all new and existing drives running in the simulation.

B. Construction

Drives 30 HP and larger shall be 12 pulse (or greater) input. Provide data and calculations showing the drive harmonics do not exceed the following numbers at the power connection to the drive.

Total harmonic voltage distortion: less than 5%

Total harmonic current distortion: less than 8%

Note: These are the maximum harmonics that can be generated by each of the drives.

The use of the following devices is permitted:

A.C. line reactors
DC chokes
KMP transformers
KMP & KFMR filter transformers

The use of the passive filter devices is not permitted:

Drives 25 HP and less shall be 6-pulse (or greater) input. Provide data and calculations showing the drive harmonics.

5% line reactors shall be provided on each drive as a minimum.

The use of the passive filter devices is not permitted:

All Drives

The variable frequency drives (Drives) shall be solid state, with a Pulse Width Modulated (PWM) output. The VFD package as specified herein shall be enclosed in a NEMA 1 enclosure, completely assembled and tested by the manufacturer. The VFD shall employ a full wave rectifier (to prevent input line notching), DC Bus Choke (s), Capacitors, and Insulated Gate Bipolar Transistors (IGBT's) as the output switching device. The drive

efficiency shall be 97% or better at full speed and full load. Fundamental power factor shall be 0.98 at all speeds and loads.

Operating Specifications

Input 380/415/440/460/480 VAC +/- 10%, 3 phase, 48-63 Hz or input 200/208/220/230/240 VAC +/- 10%, 3 phase, 48-63 Hz.

Output frequency 0 to 250 Hz. Operation above 60 HZ shall require programming changes to prevent inadvertent high-speed operation.

Environmental operating conditions: 0 to 40^{o}C, 0 to 3300 feet above sea level, less than 95% humidity non-condensing.

Enclosure shall be rated NEMA 1.

All Drives shall have the following standard features:

All Drives shall have the same customer interface including digital display, and keypad regardless of horsepower rating. The keypad is to be used for local control, for setting all parameters, and for stepping through the displays and menus. The keypad shall allow for uploading and downloading of parameter settings as an aid for start-up of multiple Drives.

The VFD shall have the ability to automatically restart after an overcurrent, overvoltage, undervoltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between restart attempts shall be programmable.

The VFD shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage (flying start). The VFD shall also be capable of DC injection braking at start to stop a reverse spinning motor prior to ramp.

The VFD shall be equipped with an automatic extended control power loss ride-through circuit, which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be one-cycle, based on full load and no inertia. Typical control power loss ride-through for a fan load shall be 2 seconds minimum. Removing power from the motor is not an acceptable method of increasing power loss ride-through.

If the input reference (4-20 mA or 2-10V) is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via keypad warning, relay output and/or over the serial communication bus.

The customer terminal strip shall be isolated from line and ground.

The drive shall employ current limit circuits to provide trip free operation:

The slow current regulation limit circuit shall be adjustable to 150% (minimum) of the Drives normal duty current rating. This adjustment shall be made via the keypad, and shall be displayed in actual amps, and not as percent of full load.

The current switch-off limit shall be fixed at 350% (minimum instantaneous) of the Drives normal duty current rating.

The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute in every 10 minutes.

The VFD shall have an integral DC BUS Choke(s) to reduce the harmonics to the power line and to increase the fundamental power factor.

The VFD shall be capable of sensing a load loss (broken belt/no water in pump) and signaling this condition via a keypad warning, relay output and/or over the serial communications bus. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false under-load condition.

The VFD shall have programmable asleep and wake-up functions to allow the drive to be started and stopped from a process feedback signal.

All Drives to have the following adjustments:

Two (2) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed.
PID setpoint controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the VFD, using the microprocessor in the VFD for the closed loop control. The VFD shall have 250 mA of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The auxiliary power supply shall have overload and over current protection. The PID setpoint shall be adjustable from the VFD keypad, analog inputs, or over the communications bus.

Two (2) programmable analog inputs shall accept current or voltage signal for speed reference, or for reference and actual (feedback) signals for PID controller. Analog inputs shall include a filter; programmable from 0.01 to 10 seconds to remove any oscillation in the input signal. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0-20 mA and 0-10 volts. Additionally, the reference must be able to be scaled so that maximum reference can represent a frequency less than 60 Hz, without lowering the drive maximum frequency below 60 Hz. Process variables shall be modifiable by math functions such as multiplication and division between the two signals (fan tracking), high/low select, as well as inverted follower.

Provide five (5) programmable digital inputs for maximum flexibility in interfacing with external devices. One digital input is to be utilized as a customer safety connection point for fire, freeze, and smoke interlocks (enable). Upon remote customer reset (closure of interlocks) the drive is to resume normal operation.

One (1) programmable analog output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, and other data.

Two (2) programmable digital relay outputs. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; maximum voltage 300 VDC and 250 VAC; continuous current rating 2 amps

RMS. Outputs shall be true form C type contacts; open collector outputs are not acceptable. Relays shall be capable of programmable on and off delay times.

Programmable preset speeds.

Independently adjustable acceleration and deceleration ramps. Ramp times shall be adjustable from 1 to 1800 seconds.

The VFD shall ramp or coast to a stop, as selected by the user.

The following operating information displays shall be standard on the VFD digital display. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of two operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):

Output Frequency
Motor Speed (RPM, %, or Engineering units)
Motor Current
Calculated Motor Torque
Calculated Motor Power (kW) DC Bus Voltage
Output Voltage
Heatsink Temperature (^{o}F)
Analog Input Values
Analog Output Value
Keypad Reference Values
Elapsed Time Meter (resettable)
kWh Meter (resettable)
mWh Meter
Digital Input Status
Digital Output Status

The VFD shall have the following protection circuits. In the case of a protective trip, the drive shall stop and announce the fault condition in complete words (alphanumeric codes are not acceptable).

Overcurrent trip 350%, instantaneous (170% RMS) of the Drives variable torque current rating.

Overvoltage trip 130% of the AFD's rated voltage.

Undervoltage trip 65% of the AFD's rated voltage.

Overtemperature +90 ^{o}C.

Ground fault either running or at start.

Adaptable Electronic Motor Overload (I^2t). The Electronic Motor Overload protection shall protect the motor based on speed, load curve, and external fan parameter. Circuits, which are not speed dependant, are acceptable. The electronic motor overload protection shall be UL approved for this function.

Speed Command Input shall be via:

Keypad

Two analog inputs, each capable of accepting a 0-20 mA, 0-10V, 2-10V signal.

Floating point input shall accept a three wire input from a Dwyer Photohelic (or equivalent type) instrument.

Serial Communications

The VFD shall have an RS-485 port as standard. The standard protocol shall be Modbus (Lon Works or BACnet are also acceptable).

The VFD shall be able to communicate with PLC's, DC's, and DDC (compatible with Honeywell and Johnson systems).

Serial communication capabilities shall include but not be limited to run-stop control; speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, and accel/decel time adjustments. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed/frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), relay outputs, and diagnostic warning and fault information. Additionally, remote (LAN) VFD fault reset shall be possible . A minimum of 15 field parameters shall be capable of being monitored.

The VFD shall allow the DDC to control the drive's digital and analog outputs via the serial interface. The serial communications interface shall allow for DO (relay) control and AO (analog) control. In addition, all drive digital and analog inputs shall be capable of being monitored by the DDC system.

The VFD shall be connectable to a PC based software tool capable of operating, programming, and monitoring the drive as well as diagnosing faults.

The following list of options shall be included:

Input disconnect breaker rated 25 KAIC.

Bypass feature shall include a bypass output contactor electrically and mechanically interlocked with VFD output contactor, run relay including control logic, status lights and a thermal motor overcurrent relay. The complete bypass system and inverter/off/bypass selector switch shall be packaged in a single VFD enclosure.

120V control transformer and circuitry

Interior heaters shall be provided to maintain the minimum drive temperature when the drive is off .

A customer interlock terminal strip. Provide a separate terminal strip for connection of fire, smoke, freeze contacts, external start command, and all digital and analog I/O points. All external interlocks and start/stop contacts shall function with drive in hand, auto or bypass. Damper control circuit shall be operable in the hand, auto and bypass.

Semi-conductor drive input fuses and spare set of fuses

C. Service

The VFD manufacturer shall provide to the Owner a start-up service package for all Drives provided. Service shall include inspector for final adjustment, operational checks, and a fault report for record purposes. The service package shall include a (1) year parts and labor warranty and (2) year parts warranty each from date of written acceptance and be performed by local factory trained service engineers. The service center must be permanently located within (200) miles of the job site and able to provide 24 hour service.

D. Factory Tests and Checks

VFD power semiconductors and diodes shall be 100% inspected and tested including load testing.

Small signal semiconductors, resistors, capacitors and diodes shall be lot sampled. Testing shall include parameter, as well as functional characteristics.

All printed circuit boards shall be tested under a temperature cycling (0 to +65 ^{o}C) 24-hour load test and then functionally tested via fault finder bench equipment prior to unit installation.

All final assemblies shall be tested at full load with application of line-to-line and line-to-ground bolted faults. The VFD shall trip electronically without device failure.

After all tests have been performed, each VFD shall undergo a 24 hour burn-in test. The drive shall be burned-in at 100% inductive of motor load for (24) hours without an unscheduled shutdown.

Upon request a copy of the burn-in test report shall be provided to the customer.

Field Tests and Checks

Testing, checkout and start-up of the VFD equipment shall be performed under the technical direction of the manufacturer's service engineer. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.

Unless waived in the RFQ the contractor shall provide independent harmonic testing by an approved testing company. Discrete and total harmonic current and voltage shall be measured and recorded at the locations and conditions listed below:

At each point of common coupling:
With all drives running under load.
With all drives off

At the power input to each drive:
With the drive running under load
With drive off

All the above data shall be submitted to the architect for review. If these tests show that the drives are not in compliance with specification the drive manufacturer shall make all changes required to comply with the specification at no cost to the owner. This shall include the total replacement of the drives that are not in compliance.

A copy of all field tests with data sheets shall be submitted to the owner for their records.

The manufacturer shall provide a one day training session for the owners maintenance workers.

Part 3 -Execution

The contractor shall receive and inspect all Drives to ensure they are received without defect. The contractor shall return all defective or damaged Drives to the manufacturer for replacement.

While in storage at the construction site the VFD shall be protected against damage at all time. The drive shall be stored in a dry environment with temperature and humidity controlled to within the ranges specified by the manufacturer. If necessary the space heaters shall be energized.

The Electrical contractor shall install all Drives.

Variable frequency drives shall be installed in accordance with manufacturer's recommendations, contract drawings, and reviewed submittals.

Drives shall be located so as to comply with all the requirement of the National Electrical code. Close attention shall be paid to the minimum clear workspace requirements of NEC article 110

The electrical contractor shall provide all supplemental steel, support, rods and hangers necessary to install the Drives.

The contractor shall properly protect all equipment to prevent damage from water, dirt, etc. Protection shall include but not be limited to temporary plastic wrap to maintain equipment in original factory condition.

Wiring installation and handling shall be in accordance with manufacturer's recommendations and the national electric code NFPA 70.

The requirement for rigid conduit below eight feet is waived for floor mounted drive enclosures that are taller than 60 inches.

All class two control wiring (DDC) shall enter the drive through a dedicated raceway system and shall be protected from contact with line voltage conductors by the application of a UL rated nylon "spiral wrap" cover over the entire length of the conductor inside the enclosure.