MOTOR STARTERS TO 600 V & VARIABLE FREQUENCY DRIVES

1. GENERAL

1.1 Related Work

.1 Electrical General Requirements — Section 16010

.2 Connections to Mechanical Equipment: — Section 16950

1.2 Starter Requirements

.1 In general, there are categories of starting equipment for three phase motors.

.1 Integral Mounted Starters: Some items of mechanical equipment such as boilers, have the starter mounted as part of the equipment. For this equipment, supply disconnects and wire to the terminals of the equipment.

.2 Separately Mounted Starters: For motors without integral mounted starters, supply separately mounted starters as indicated on the Drawings and wire the equipment.

.3 Starters in Motor Control Centres: For motors fed from motor control centres, wire from the equipment to the motor control centres.

.2 Provide manual starters for all single phase motors unless otherwise indicated on the motor schedule.

.3 Provide interlocking between starters where required.

.4 All starter accessories such as pilot lights, Hand-Off-Auto, Start-Stop, etc. whether integrally or remote mounted shall be heavy duty oil tight, unless otherwise specified.

1.3 Shop Drawings and Product Data

.1 Submit shop drawings in accordance with Section 16010 – Electrical General Requirements.

.2 Indicate:

.1 Mounting method and dimensions
.2 Starter size and type
.3 Layout of identified internal and front panel components
.4 Enclosure types
.5 Wiring diagram for each type of starter
.6 Interconnection diagrams.

1.4 Operation and Maintenance Data

.1 Provide operation and maintenance data for motor starters for incorporation into manual specified in Section 16010 – Electrical General requirements.

.2 Include operation and maintenance data for each type and style of starter.

2. PRODUCTS

2.1 Materials

.1 Starters: Nema rated.

2.2 Enclosure

.1 All individually mounted motor starters shall be enclosed in a general purpose sheet steel enclosure unless in wet areas where they shall be watertight EEMAC 4.

2.3 Manual Motor Starters

.1 Manual motor starters of size, type, rating, and enclosure type as indicated, with components as follows:

.1 Switching mechanism, quick make and break
.2 Overload heaters, manual reset, trip indicating handle
.3 Rated volts and poles to suit application.

.2 Accessories:

.1 Toggle switch: standard labelled as indicated.

.2 Indicating lights: standard heavy duty type and colour as indicated.

.3 Locking tab to permit padlocking in "ON" or "OFF" position.

2.4 Full Voltage Non Reversing (FVNR) Magnetic Starters

.1 Provide motor starters of the electro-mechanical type with the coil controlled by an application specific microprocessor.

.2 Provide one (1) current sensor accurate to 2% for each phase to provide motor running overload protection that yields a time current curve closely paralleling that of the respective motor heating damage boundary. Running overload protection shall be DIP switch selectable for the specific motor full load amperes.

.3 Provide DIP switch selectable overload trip class of 10, 20 and 30.

.4 Provide phase loss protection and phase unbalance protection. If the phase unbalance on any of two phases is greater than 30% of the DIP switch selected trip rating, a phase loss/unbalance trip occurs.

.5 Provide ground fault protection set at 20% of maximum continuous ampere rating with a start delay of 17 seconds, and a run delay of 0.4 seconds to prevent nuisance tripping on startup.

.6 Provide each motor starter with a snap-in window which allows clear visibility of overload DIP switch settings and prevents unwanted tampering of DIP switch settings once installed.

.7 Provide an application specific microprocessor with the following features:

.1 Microprocessor shall measure control circuit voltage and prevent closing of the coil on voltages below 78 volts AC and/or voltages above 135 volts AC.

.2 Microprocessor shall apply voltage to the coil such that a guaranteed maximum of two (2) milliseconds of main contact bounce occurs on contactor closure.

.3 Microprocessor shall continuously measure coil circuit voltage and current so as to maintain constant coil power at a level to maintain main contact closure and minimize coil power consumption.

.4 Provide electronic circuitry that isolates the coil and is isolated from surges.

.5 Microprocessor shall wait for three (3) half-cycles of control start signal prior to activating a close to prevent starts resulting from momentary voltage spikes, switching transients, fluttering contacts, and shorted programmable logic control outputs. The phase angle of the power in the control circuit is to be compared with the phase angle of the input start signal to prevent starts resulting from capacitively coupled or inductively coupled signals.

.8 Motor starters shall have replaceable fixed and movable contacts.

.9 Accessories

.1 Motor starter shall be designed to accommodate two (2) auxiliary contact blocks, each capable of a combination of up to four (4) normally closed or four (4) normally open auxiliary contacts. Contacts to be color-coded; black designating NC and silver designating NO. Contacts to be rated ten (10) amperes continuous, 7200 VA make, 720 VA break for 120 through 600 volts AC, and 69 VA make and break for 125 through 300 volts DC. Provide a minimum of one (1) spare NO contact and one (1) spare NC contact in addition to any auxiliary contacts required.

.2 Provide control modules to perform the indicated input/output control functions as shown on the contract drawings. Module to incorporate faceplates having membrane-type pushbuttons and LEDs. All pushbutton and LED functions shall be furnished with clearly written identification. Control modules shall be provided with 6-foot connection cord and single plug-in wiring to accommodate jack provided in the contactor. Provide as required, modules available to cover applications ranging from full-voltage non-reversing, reversing, multi-speed, and reduced voltage. Modules to be provided with the ability to replace conventional "start", "stop", "hand", and "auto", control functions, and when utilized in starter applications. Modules to be provided with the ability to replace conventional indicating light status of "run", "off", "overload alarm", and "overload trip" when utilized in starter applications.

.10 Microprocessor-based motor control shall be Cutler-Hammer IT Series or approved equal.

2.5 Variable Frequency Drives

.1 This section establishes the requirements for the design, fabrication, inspection, testing, delivery and installation of variable frequency drive (VFD) controllers and ancillary equipment packaged into a motor control centre as indicated on drawings or standard enclosure for wall or free standing arrangements where so indicated on drawings.

.2 Shop assemble and pre-wire the equipment.

.3 All drives and ancillary components to be supplied by one manufacturer to assure a properly coordinated system.

.4 Use standard "off the shelf" designs. No field modified or custom designed system will be allowed.

.5 Design all equipment using modularized solid state equipment to allow easy maintenance and replacement.

.6 Submit shop drawings in accordance with Sections 16010.

.1 Provide:

.1 Catalog and technical data.

.2 Outline dimensions, shipping section dimensions, weight, and foundation requirements for all assemblies.

.2 Control schematics.

.1 External connection diagram showing function and identification of all terminals requiring field connections.

.2 Line harmonic distortion calculations. The total system's harmonics to be addressed as a complete system study as to what is required in the way of harmonic filters to attenuate THD (total harmonics distortion). The single line and/or impedance diagram of the electrical site system to be provided by the Engineer.

.3 Component fabrication drawings consisting of detailed circuit schematics, printed circuit board drawings, and chassis layouts for all electrical and electronic components.

.4 Manufacturer's certification that VFD can withstand applicable short circuit fault conditions.

.5 Manufacturer's certification that VFD can withstand environmental conditions.

2.5.1 Submittals For Information Only

.1 Provide operation and maintenance data for variable frequency drive controllers for incorporation into manual.

.2 To include, but not be limited to:

.1 All shop drawings information listed above. Troubleshooting flowcharts for all device fault.

.2 An instruction manual for programming and hardware provided with the equipment at time of shipment.

.3 Setting sheets to record all VFD configuration options/selections for drive setup.

2.5.2 Reference Standards

.1 Confirm to the following reference standards in accordance with Section 01090:

.1 ANSI C-343.
.2 CSA
.3 EEMAC.
.4 IEEE STD 444, IEC 146A standards.
.5 NEMA MG1.

.2 All units to be UL listed, CSA approved.

2.5.3 Unit Responsibility

.1 The VFD's specified in this section to be product of a single manufacturer.

.2 The driven equipment supplier assumes total system responsibility for the motor to be VFD compatible as per NEMA MGI Part 31, 1993, Rev.1.

2.5.4 Vendor Qualifications

.1 General

The acceptable drive vendor to provide a factory trained sales force in the North West Territories or in the province of Alberta, available for consultation to answer any application and maintenance questions.

.2 Vendor Service

The acceptable vendor to have a distributor organization which stocks standard drives, modification kits and spare parts in the North West Territories or in the province of Alberta.

.3 Vendor Organization

The acceptable vendor to be factory trained service representatives on staff. The factory representative to be trained in the maintenance and troubleshooting of the equipment as specified herein.

2.5.5 Quality Assurance

.1 The following terms are used for the purpose of describing quality assurance and testing requirements:

.1 Factory Tests: testing of components and systems at the manufacturing level.

.2 Shop Tests: testing of assembled system prior to shipping to site. Field Tests: testing of installed system prior to or as part of the start-up phase; refer to part 3 of this specification.

2.5.6 Acceptable Manufacturers

.1 Cutler Hammer, Schneider Electric, ABB, Hitachi, or approved equal.

2.5.7 Ambient

.1 The VFD to be suitable for use in normal indoor non-hazardous industrial environments subject to the following conditions.

.2 For enclosed units, an ambient temperature range of 0 to 40C.

.3 For open units, an ambient temperature of 0 to 50C.

.4 For all units, a humidity range from 5 to 95%, non-condensing.

.5 For all units, an altitude range up to 1,000 meters without derating the VFD's output power capability.

.6 To ensure adequate heat dissipation the VFD unit is to include fan assisted cooling such that it would not degrade the enclosure rating. When forced cooling is used, provide alarm status and shutdown of VFD on fan loss.

2.5.8 Construction

.1 Design the VFD to provide for ease of maintenance.

.2 The VFD shall consist of the following major components:

.1 Input rectifier section to supply fixed DC bus voltage.
.2 DC bus capacitors.
.3 Open loop Vector Control generating inverter section.
.4 Suitable snubber circuitry to control output voltage spikes and to control rise times of the output pulses.
.5 Built in ground fault protection.
.6 Input line reactors with a minimum of 5% per unit impedance.
.7 The VFD vendor to provide a minimum of a 5% output reactor, harmonic compensated filter network to limit dv/dt rise to motors on 575 volt systems only.

.3 In each VFD include, as standard, a fully digital display which will display programming, operation, and fault code diagnostic information. This display to be mounted on the MCC enclosure door.

.4 Separate the VFD power terminal blocks physically from control signal terminal blocks.

.5 The VFD shall be modularly constructed. Provide printed circuit boards with plug-in connections and easily removable from the drive. Provide power components readily accessible with screw terminal connections for easy removal.

2.5.9 Equipment Enclosure

.1 The VFD are to be mounted EEMAC 1 enclosure.

.2 Shop Assemble and pre-wire the equipment. Include in each VFD unit:

.1 Fused disconnect switch or circuit breaker as main isolation disconnect.
.2 Variable frequency drive controller complete with accessories.
.3 Bypass solid state reduced voltage starter.
.4 Mechanically interlocked magnetic motor contactors, for VFD output and Bypass operation.
.5 Input 5% iron core line reactor as a minimum.
.6 Output line reactor filters for 575 volt inverter duty motors only.

.7 Fused primary (2) and Secondary (1) 120 Vac control transformer with 50VA surplus capacity.

.8 Thermal overload for motor protection for each motor in bypass operation.

2.5.10 System Requirements

.1 Motor Operation

.1 The nominal VFD rating is based on a EEMAC Type B, inverter duty, AC induction motor with Standard or High efficiency construction having a 1.15 service factor. Determine final VFD selection by load type, full load motor current and special requirements (if any) listed in Equipment List.

.2 Unless otherwise noted elsewhere the EEMAC Type B Premium Efficiency inverter duty AC induction motor to be used to operate a variable or constant torque load over a 30 to 110% speed range reaching rated nameplate horsepower (hp) at 60Hz.

2.5.11 Electrical Design Characteristics

.1 Input Power

.1 Unless otherwise specified, the VFD to accept nominal supply voltage 575V +15% 3-phase 60 Hz, grounded power supply.

.2 Permit variations of up to +2 Hz of line frequency without the VFD shutting down on a fault.

.3 Permit power line interruptions of up to 2.0 seconds without the VFD shutting down on a fault providing an extended power loss ride-through. If the drive trips on under voltage, the drive will activate the Automatic Restart/Reset for under voltage trips and the rotating start function to allow the drive to restart immediately when the power returns, and match the motor rotating speed and take control.

.4 The VFD not to exceed the notch depth of 20%, the total harmonic distortion factor (THD) of 5%, total demand distortion of 10% and the notch area of the line-to-line voltage to be maximum 28,500 volt-microseconds at rated voltage an current, as specified in IEEE 519, latest edition.

.5 The VFD shall present a displacement power factor of 0.98 or better to the AC line at any speed or load. True full load power factor shall be 90% or better.

.6 Efficiency of VFD controller shall be not less than 98% at 60 hertz output when driving the specified maximum load.

.7 The variable frequency control to operate satisfactorily when connected to a bus supplying other solid state power conversion equipment which may be causing up to 5% total harmonic voltage distortion and communication notches up to 36,500 volt microseconds.

.8 The VFD to include transient voltage suppression to allow reliable operation encountered in an industrial/commercial power distribution system for transients up to 3000V, 50 JOULES.

.2 Output Power

.1 The VFD to produce a three phase output for the load.
.2 The VFD to be of the Open Loop Vector Control Modulated type and to consist of a full wave diode bridge converter to convert incoming fixed voltage/frequency to a fixed DC voltage. The Vector Control strategy shall incorporate a microprocessor to handle all Logic functions as well as the complex, pulse generating algorithms that control output stage switching. Generate the inverter output by IGBT power transistors only.
.3 Unless otherwise specified, the standard VFD output frequency to be adjustable from 0 to 90 Hz.

2.5.12 Protective Features

.1 Incorporate the following protective features with each VFD:

.1 Disconnect switch with fuses.
.2 Short Circuit Protection: Instantaneous overcurrent protection, including short circuit phase-phase or phase-ground by high speed fuses with 100,000 ampere fault capacity rating.
.3 Fully protect the VFD against load faults. Bolted faults, phase to phase or phase to ground, shall not damage the unit. Design VFD to withstand the short circuit currents.

.2 Adjustable current limit from 50 - 150% (50 - 135% for variable torque loads) rated current of unit. The VFD to avoid nuisance current trips caused by short acceleration or deceleration settings by temporarily increasing the acceleration or deceleration times.

.3 Phase Protection

.1 Each output phase to be monitored. If a short circuit condition occurs, a circuit shall guard against further damage by turning off the entire output section experiencing the shorted condition.
.2 The VFD to shut down and annunciate the fault and display the appropriate fault code on the digital display panel.

.4 Over voltage Sensing

.1 Should either the input line rise above 15% of rated input voltage, or the internal DC bus rise above allowable levels due to load regeneration, the VFD to sense an over voltage condition and annunciate it on the digital display panel and alarm contact.
.2 The VFD to trip if the DC voltage exceeds 125% of rated voltage. The VFD to compensate for over voltages caused by short deceleration settings by automatically increasing the decelerating time in order to avoid nuisance over voltage trips.

.5 Under Voltage Sensing

.1 Should the input line fall below 85% of rated input voltage, the VFD to sense an under voltage condition and annunciate it on the digital display panel.

.6 Motor Overload Protection

.1 Provide the VFD with a separate motor overload protection for each motor connected to the drive.

.2 The overload protection to be adjustable from 80 to 115% of the full load current rating.

.7 Motor Over Temperature Protection

.1 Provide the VFD with a positive temperature coefficient thermistor (PTC) over-temperature device installed in motor to shut down system if the motor becomes overheated. Provide status indication for motor over temperature.

.8 Heat Sink Temperature

.1 The VFD to monitor the temperature of the heat sink. If the heat sink temperature exceeds design/limits the VFD shall shut down and annunciate the condition on the digital display panel.

.9 Ground Fault Detection

.1 Should an output phase short to earth ground occur, the VFD to have circuits to guard against excessive currents. This condition to be monitored and annunciated on the digital display panel.

2.5.13 Control Features

.1 General

.1 Provide two galvanically isolated analog inputs which are both capable of operating from 4-20 mA.

.2 A linear and tapered curve suitable for drives requiring controlled acceleration/deceleration.

.3 Provide offset and gain programmable functions to set operating range.

.4 Provide two (2) 4-20 mA galvanically isolated analog outputs which can be programmed to be proportional to:

.1 Output motor current
.2 Motor speed.

.5 All VFD set-up operations and adjustments to be digital and stored in a nonvolatile memory (EEPROM). No analog or potentiometer adjustments to be allowed.

.6 The VFD to be capable of communicating with a communication device over the remote I/O serial link, multi-drop, typically RS485, using industry standard communication protocol. Provide software to upload and download parameters via labtop computer.

.2 Speed Droop: a speed droop feature which reduces the speed of the drive on transient overloads. The drive is to return to set speed after transient is removed. If the acceleration or deceleration rates are too rapid for the moment of inertia of the load, the drive is to automatically compensate to prevent drive trip.

.3 Speed Profile: individual adjustable settings for start, stop, slope, and minimum and maximum speed points.

.4 Process Signal Inverter: software selectable to allow speed of drive to vary inversely with input signal.

.5 Digital Interface

Provide a local interface to upload, download and read drive parameter settings through the use of a personal computer or a similar portable device.

.6 Pick up a Spinning Load (Rotating Start): The VFD shall be programmable for rotating start, enabling the VFD to start into a rotating motor, regardless of direction, without tripping and without setting the motor to zero speed. The VFD to start at the speed the motor is rotating and then accelerate the motor according to the speed reference signal.

.7 Bumpless speed transfer: Provide a bumpless speed transfer from remote control to local control, without setting the motor to zero speed.

.8 Automatic Reset/Restart

.1 Provide software programmable automatic reset/restart after any individual trip condition resulting from either overcurrent, over voltage, under voltage, or over temperature.

.2 For safety, the drive shall shut down and require manual reset if the automatic reset function is not successful within a maximum of three attempts within a short time period.

.9 IR Compensation

Complete set of parameters (programmable range) which allows for extra torque to be applied at speeds between 0.1 Hz and the set field weakening point, 140% rated torque shall be produced with 150% rated current.

.10 Torque Compensation

The automatic boost in torque to handle impulse loads or demands for fast acceleration by momentarily increasing the output volt/hertz ratio. When selected, the function to be operative at all speeds even under overload conditions, and eliminates the motor speed droop that would otherwise occur.

2.5.14 External Control and Monitoring

.1 General

Provide isolation and voltage surge suppression for contacts used for external monitoring to limit inductive switching surges to less than 200 V peak. Provide DC coils with free-wheeling diodes to limit inductive surges to 28 V peak.

.2 Wiring

Use twisted shielded pairs for control and signal wiring that connects external to the VFD. Separate signal and power wiring that may contain voltage and/or current harmonics inherent to inverter.

.3 Digital Operator Station (Front Panel)

.1 Provide an operator station on the drive door complete with the following features as a minimum:

.1 START pushbutton for local VFD control
.2 STOP pushbutton for local VFD control
.3 Start and Stop pushbuttons for Bypass control in "Local" mode
.4 Speed raise / lower pushbuttons with digital frequency display for local speed adjustment
.5 VFD RUN light
.6 VFD FAULT light
.7 Inverter - Off - Bypass selector Switch
.8 Local - Off - Remote control selector switch
.9 Green "Run" Pilot Lamp
.10 Red "Bypass On" Pilot Lamp
.11 Speed Indication
.12 Motor Current Indication.

.4 Speed Control

.1 The VFD to contain an independent parameter which provide an adjustable minimum speed setting from 0 to 60 Hz.

.2 The VFD to contain an independent parameter which provides an adjustable maximum speed setting from 40 to 90 Hz.

.3 The VFD to accept an isolated analog input speed reference of 4-20 mA and be adjustable via the digital operator station.

.4 The 4-20 mA analog input speed reference signal to be galvanically isolated. Calibration adjustments shall be provided within the speed ranges specified.

.5 Selectable stopping modes of coast, ramp to stop or DC brake to stop shall be available.

.6 Provide one adjustable skip frequencies with programmable band width.

.5 Drive Controls

.1 Provide control transformer, fuses, terminal blocks and control relay(s) interconnected in accordance with the project requirements.

.2 The VFD to accept an isolated output signal via DCS to stop and start the drive.

.3 The VFD inverter to have capability to interlock of 3n/c external interlocks.

.4 The VFD to provide 3 isolated form C contact outputs rated for 120Vac. Status of contacts to indicate:

.1 Run
.2 Ready
.3 Fault.

.5 The Drive to be wired to achieve the following functionality:

.1 Motor selected to "Remote" enables motor to be started, stopped and speed to be adjusted via BCS.
.2 Motor selected to "Local" enables motor to be started, stopped and speed to be adjusted via the front panel pushbuttons.

2.5.15 Drive Protection/Fault Annunciation

The VFD to be capable of monitoring the following conditions or sensing the following faults. Where indicated in the following text, the condition or fault shall be annunciated on the diagnostic display panel. The panel to be mounted on the front of the VFD and visible through the door of the enclosure. The VFD to instantaneously shut down when a fault condition occurs.

.1 Short circuit protection
.2 DC bus under voltage protection
.3 DC bus over voltage protection
.4 Over temperature protection
.5 Power semiconductor protection
.6 Ground Fault protection.

2.5.16 Parameter Settings

.1 Provide the following system configuring settings, field adjustable through the keypad/display unit or via the serial communication port.

.2 Motor configuration data:

- .1 Motor frequency
- .2 Number of poles
- .3 Full load speed
- .4 Motor volts
- .5 Motor full load amps
- .6 Motor HP.

.3 VFD limits:

- .1 Independent accel/decel rates
- .2 No load boost
- .3 Vmin, Vmax, V/Hz
- .4 Full load boost
- .5 Overload trip
- .6 Min/Max speed (frequency)
- .7 Auto reset for load or voltage trip select
- .8 Slip compensation
- .9 Rotating Start select
- .10 Overload trip time.

.4 Controller Adjustments:

- .1 Minimum frequency 0 - 60 Hz.
- .2 Maximum frequency 40 - 90 Hz.
- .3 Acceleration time 0.3 - 255s.
- .4 Deceleration time 0.3 - 255s.
- .5 Output current 50 - 150% of nominal current for constant torque. Output current 50 - 125% for variable torque application minimum.
- .6 Speed range 0 - 110%.
- .7 Start by: Normal acceleration or, automatic start boost or rotating start.
- .8 Stop by: Coasting or, normal deceleration or, braking.
- .9 Slip compensation.
- .10 Electronic o/l adjustment.
- .11 Automatic restart after over voltage.
- .12 Automatic restart after under voltage.
- .13 IR compensation boost between 15 - 45V depending on size of unit.
- .14 Linear or tapered V/Hz ratio.
- .15 Selection of field weakening point (V/Hz ratio).
- .16 Automatic start boost, programmable, active only at start until output frequency reaches 20 Hz or set speed reference less than 20 Hz.

2.5.17 Diagnostic Features and Fault Handling

.1 Provide a microprocessor based digital diagnostic system which monitors its own control functions and displays faults and operating conditions. Microprocessor systems must be product of the same manufacturer as the VFD to assure single source responsibility, availability of service and access to spare parts.

.2 The digital keypad allows the operator to enter exact numerical settings. A plain English user menu shall be provided in software as a guide to parameter setting, (rather than codes). Drive parameters shall be factory set in EEPROM and be resettable in the field through the keypad. Multi levels of password security shall be available to protect drive parameters from unauthorized personnel. The EEPROM stored drive variables must be able to be transferred to new boards to reprogram spare boards.

.3 The VFD to execute, on initial power-up, a self diagnostic check. The integral programming display panel shall provide first fault indication of VFD protection functions. Fault indication to be retained if input power is lost. The following faults to be displayed on the local programming panel:

.1 Overcurrent
.2 Short Circuit/Ground Fault
.3 Under voltage
.4 Over voltage
.5 Over temperature
.6 Power Supply Fault
.7 Motor stalled

.1 Fault codes to provide direction as to board level and input/output level to aid in trouble shooting.
.2 The fault log record shall be accessible via a RS485 serial link as well as line by line on the keypad display.
.3 Self diagnostic check to indicate faulty internal components.

2.5.18 Factory Testing

.1 Provide certification that the following tests have been successfully completed.

.2 Factory tests include but are not limited to:

.1 Testing of power transistors, diodes and other solid state components to ensure correct function and highest reliability.

.2 All control printed circuit boards shall be dynamically tested while heat cycled.

2.5.19 Bypass

.1 Provide for a manual bypass control scheme to safely apply full voltage to the driven motor in the event of a failure to the Adjustable Speed Drive. The bypass scheme shall meet the following minimum requirements:

.1 Provide HRC time delay bypass line fuses after the door interlocked fusible disconnect.

.2 Provide primary and secondary fused 120 Vac control power.

.3 Provide motor starter contactor for Bypass and AFD operation. Selection of mode of operation will be via integral mounted Inverter-OFF-Bypass selector switch.

.4 Provide a thermal overload relay sized to protect the motor for either mode of operation.

.5 Provide a Local-Off- Remote selector switch and a interposing relay to select the run/stop operation in conjunction with BYP-OFF-AFD switch as follows:

.1 "Inverter" MODE:

.1 Selector switch in "Local" position.
.2 VFD operated by panel mounted start and stop pushbuttons, speed controlled by the keypad.
.3 Selector switch in "OFF" position VFD cannot be started.
.4 Selector switch in "Remote" position VFD operates by remote start/stop command, the speed controlled by the isolated 4 - 20mA signal.

.2 BYPASS MODE:

.1 "Local" position starts Bypass manually via panel mounted "Bypass start and stop pushbuttons".
.2 "OFF" position prevents motor from operating.
.3 "Remote" position allows motor to start by remote start/stop command.
.4 NOTE: All Interlocks are in the circuit for all modes of operation.

2.5.20 Structure Installation

.1 Install variable speed drives with the assistance of factory-trained engineers in accordance with the manufacturer's specifications.

.2 Coordinate with motor control centre supplier for the supply and installation of the drive into the motor control centre.

2.5.21 Field Test

.1 Provide manufacture engineers to test and calibrate each VFD. Allow for 1/2 day per system.

.2 Provide written report of commissioning test including all parameter settings.

.3 Reference Sections 16960, 16980 and 16990 for details of commissioning requirements.

2.5.22 Documentation

.1 Provide operating and maintenance manuals.

.2 Provide as tested, as built, find power and connection drawings.

.3 Provide as left parameter settings for all functions.

2.5.23 Training

.1 Provide operator training and maintenance and servicing seminar for 1/2 day.

.2 The on site training to cover the following topics as a minimum:

.1 Theory

.2 Configuration/models

.3 Setup

.4 Maintenance

.5 Troubleshooting.

3. EXECUTION

3.1 Installation

.1 Install starters, variable frequency drives, connect power and control as indicated.

.2 Ensure correct overload devices elements installed.

3.2 Starter Verification

.1 Field check motor starters and variable frequency drives, supplied prior to commissioning equipment. As a minimum, verify the following:

.1 Check of control circuits
.2 Verify that overload relay installed is correctly sized for motor used

.3 Record overload relay size and motor nameplate amperage
.4 Ensure all connections are tight.

.2 Measure and record motor amps, under load conditions and compare with full load amps and motor service factor. Report any excessive readings and unbalance. Measure voltage as close to motor terminals as possible while motor is running

.3 Set all motor circuit protectors to the minimum level which will consistently allow the motor to start under normal starting conditions.

3.3 Overload Relays

.1 For starters provided, select overload relays in accordance with relay and motor manufacturers' recommendations, considering motor service factors, ambient temperature, temperature differences between motor and starter locations. Monitor motor operation during startup to ensure motor operation is satisfactory and relays provide proper protection. For side inlet fans and other long acceleration time loads, provide special overload relays to suite the start-up condition. Provide manufacturers' curves and data sheets where necessary to provide supporting data for motor protection.

3.4 Field Quality Control

.1 Perform tests in accordance with Section 16980 - Testing, Adjusting and Balancing of Electrical Equipment and Systems and manufacturer's instructions.

.2 Operate switches, contactors to verify correct functioning.

.3 Perform starting and stopping sequences of contactors and relays.

.4 Check that sequence controls, interlocking with other separate related starters, variable frequency drives, equipment, control devices, operate as indicated.

END OF SECTION

CONNECTIONS TO MECHANICAL EQUIPMENT

1. GENERAL

1.1 Related Work

.1 Mechanical: Division 15

.2 Motor Starters: Section 16811

1.2 Requirements

.1 Provide a complete system of wiring to motors and controls as specified herein and as shown on the drawings.

.2 Unless specifically noted otherwise, wire and leave in operation all electrically operated equipment supplied under all contracts related to this project. Examine the drawings and shop drawings of all Divisions for the extent of electrically operated equipment supplied under other contracts.

.3 All control wiring diagrams shown on the drawings illustrate typical control circuits applicable to the equipment. Control circuits may vary with different manufacturers of equipment. Verify all control circuits with the suppliers of the equipment and make any corrections that may be required.

.4 Unless specifically noted otherwise, supply all pushbuttons, relays, starters, etc., necessary for the operation of equipment. Check all starters, relay coils and thermal elements to ensure that they provide the necessary protection for motors.

.5 Do not operate motors and controls until approval is obtained from the trade providing equipment.

.6 Examine drawings and shop drawings of other Divisions to obtain exact location of motors and equipment shown on drawings. Where necessary, obtain conduit locations from other trades' drawings and shop drawings.

.7 Assist in placing in operation all mechanical equipment having electrical connections.

.8 Provide three phase starters with fused 120 volt control transformers and overload relays.

.9 Provide all power wiring for all motors and control wiring as indicated on the drawings.

.10 In general, wiring for freezestats, firestats, E.P. switches, P.E. switches, dampers, temperature controllers, flow switches, solenoid valves, etc., for heating ventilating and air conditioning equipment will be under a separate contract. Provide terminations in starters and MCCs for control wiring so that starter control circuits may be extended. Where 120 volt power is required for mechanical equipment, i.e. control cabinets, etc. wiring to the equipment terminals is the work of this Division.

.11 Refer to Motor Control Equipment Schedule.

.12 Some specific definitions of equipment wiring responsibilities are as follows:

.1 Process Pumps

.1 Provide all 120V 600 V wiring for this equipment. Provide all 120V control wiring to control panel to provide pump operation and interlocking as shown on the drawings.

.2 Fans

.1 Provide all 120V and 600 V power wiring. Except where specifically noted otherwise, all control for fans is to be supplied, installed and wired from the starter control circuits to the equipment under Division 15.

.3 Pumps for Domestic Water, Plumbing & Drainage Systems

.1 Provide all 120V and 208V and 600 V power wiring. Except where specifically noted otherwise, all control for pumps is to be supplied, installed and wired from the starter control circuits to the equipment under Divisions 15 or 17.

.4 Unit Heaters

.1 Provide power wiring and starters for unit heater fans. Install and wire line voltage thermostats supplied by others. Where thermostats are low voltage or pneumatic, control wiring is under Division 15.

.5 Forced Flow Convectors

.1 Provide 120V power supply to the convectors. Starters, speed controllers and temperature controllers will be supplied and wired under Division 15.

2. PRODUCTS

2.1 3 Phase Motor Disconnect Switches

.1 Industrial Type "A", having quick make, quick break visible blade mechanism, cover interlocks and padlocking switch in the closed or open position. Use EEMAC 4 enclosures outdoors, and EEMAC 1 indoors switches to be H.P. rated, Westinghouse heavy duty type.

2.2 120 Volt, 1 Phase Disconnect Switches

.1 Manual starter without overload relay.

2.3 208 Volt, 1 Phase Motor Disconnect Switches

.1 Manual starter without overload relay.

3. EXECUTION

3.1 Installation

.1 Provide disconnect switches adjacent to all motors.

.2 Provide all wiring between all force flow and unit heaters and their thermostats. Install wiring between all flow switches and valve monitors and the fire alarm panel.

.3 Do control wiring as indicated on the drawings and the motor control schedules.

END OF SECTION

STARTING OF ELECTRICAL EQUIPMENT AND SYSTEM

1. GENERAL

1.1 Related Work

.1 Testing, Adjusting and Balancing of Electrical Equipment and Systems: Section 16980

.2 Electrical Equipment and Systems Demonstration and Instruction: Section 16990

1.2 Coordination

.1 Coordinates starting of electrical equipment and systems with testing, adjusting and balancing, and demonstration and instruction of:

.1 Electrical equipment and systems specified in Division 16.

.2 Mechanical equipment and systems specified in Division 15.

.3 Other equipment and systems specified in other Divisions.

.2 Where any equipment or system requires testing, adjusting or balancing prior to starting, ensure that such work has been completed prior to starting of electrical equipment and systems.

2. PRODUCTS (NOT USED)

3. EXECUTION

3.1 Energizing Main Electrical System

.1 Prior to energizing main electrical system:

.1 Verify supply authority voltage and phase rotation.

.2 Verify voltage and phase rotation of the standby generator.

.3 Close and open all devices to ensure proper mechanical operation.

3.2 Starting Motors

.1 Prior to starting motors:

.1 Verify phase rotation at motor control centres.

.2 Confirm motor nameplate data with motor starter heater overloads.

3.3 Energizing Equipment

.1 Prior to energizing equipment provided under other Sections and equipment provided by the Owner.

.2 Confirm equipment nameplate data with characteristics of power supply.

END OF SECTION