

SECTION 230514 – VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 WORK INCLUDES

- A. Base Bid:
 - 1. Contractor Shall Provide:
 - a. Variable frequency drive (VFD) packages for specified equipment. VFD's shall be provided with the Building Automation System. Refer to Section 230900 – HVAC Instrumentation and Controls.

1.2 REFERENCES

- A. NFPA 70 - National Electrical Code.
- B. NEMA ICS 3.1 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

1.3 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years experience.
- B. The complete VFD, including all optional features, shall be factory tested. The VFD shall operate a dynamometer at full load and the load and speed shall be cycled during the test.

1.4 REGULATORY REQUIREMENTS

- A. Conform to requirements of NFPA 70.
- B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Accept controllers on site in original packing. Inspect for damage.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosure, and finish.

1.6 FIELD MEASUREMENTS

- A. Verify that field measurements are as indicated on shop drawings.

1.7 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Wiring Diagrams: For power, signal, and control wiring.
- C. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES

- A. Manufacturers:
 - 1. Square D.
 - 2. Toshiba.
 - 3. ABB.
 - 4. Danfoss.
- B. Equipment requiring VFD:
 - 1. AHU-1:
 - a. Supply Fan: 15 HP
- C. General:
 - 1. The control system shall include as, a minimum adjustable frequency drive(s) and remote sensor/transmitters as indicated on the plans. Provide additional items as specified or as required to properly execute the sequence of operation.
 - 2. Provide complete variable frequency drives as specified herein for pumps as indicated on the schedules. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. VFD shall be housed in a metal NEMA 1 enclosure.
 - 3. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control.
 - 4. An advanced sine wave approximation and voltage vector control shall be used to allow operation at rated motor shaft output at nominal speed with no derating. This voltage vector control shall minimize harmonics to the motor to increase motor efficiency and life.
 - 5. The VFD shall include a full-wave diode bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.
 - 6. The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be UL listed.
 - 7. The VFD shall have a DC line reactor to minimize power line harmonics. VFD's without a DC line reactor shall provide a 3% impedance line reactor.
 - 8. The VFD's full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be

able to provide full rated output current continuously, 110% of rated current for 60 seconds and 220% of rated current for up to 1 second while starting.

9. An automatic energy optimization selection feature shall be provided standard in the drive. This feature shall reduce voltages when lightly loaded and provide a 3% to 10% additional energy savings.
10. Input and output power circuit switching can be done without interlocks or damage to the VFD.
11. Drive shall be capable of switching motors on output without damage to the drive. This capability shall not require interlocks with the VFD.

D. Protective Features:

1. Class 20 I2t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications.
2. Protection against input transients, loss of AC line phase, short circuit, ground fault, overvoltage, undervoltage, drive overtemperature and motor overtemperature. The VFD shall display all faults in plain English.
3. Protect VFD from sustained power or phase loss. The VFD shall incorporate a 5 second control power loss ride through to eliminate nuisance tripping.
4. The VFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.
5. The drive shall be fitted with output line reactors to limit the rate of output voltage rise over time (dV/dt), reduce motor operating temperature and RFI and EMI. To prevent breakdown of the motor winding insulation, the dV/dt must be below 1500 V/μsec per IEC recommendations. The supplier shall include with the quotation the dV/dt values of the drive.
6. Drive shall catch a rotating motor operating forward or reverse up to full speed.

E. Interface Features:

1. Local/Hand, Stop/Reset and Remote/Auto selector switches shall be provided to start and stop the drive and determine the speed reference.
2. Provide a 24 V DC, 40 mA max, output signal to indicate that the drive is in Remote/Auto mode.
3. Digital manual speed control.
4. Lockable, alphanumeric backlit display keypad can be remotely mounted up to 10 feet away.
5. VFDs up to 300 HP shall use the same control panel.
6. Displays shall be in the English language.
7. A red FAULT light and a green POWER-ON light shall be provided.
8. A quick setup menu with preset parameters shall be provided on the drive.
9. Set point control interface (PID control) shall be standard in the unit.
10. Floating point control interface shall be provided to increase/decrease speed in response to switch closures.
11. An elapsed time meter and kWh meter shall be provided.
12. The following displays shall be accessible from the control panel in actual units:
 - a. Reference Signal Percent.
 - b. Output Frequency.
 - c. Output Amps.
 - d. Motor HP.
 - e. Motor kW.
 - f. kWhr.
 - g. Output Voltage.
 - h. No Load Warning.
 - i. DC Bus Voltage.

- j. Drive Temperature (% until trip).
 - k. Motor Speed in engineering units per application (in percent speed, GPM).
 - 13. Drive will sense the loss of load and signal a no load/broken belt warning or fault.
 - 14. The VFD shall store in memory the last 8 faults and record all operational data.
 - 15. Eight programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
 - 16. Two programmable relay outputs shall be provided for remote indication of drive status.
 - 17. Two programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include 0-10 V dc, 0-20 mA and 4-20 mA.
 - 18. Two programmable analog outputs shall be provided for indication of drive status. These outputs shall be programmable for output speed, voltage, frequency, amps and input kW.
 - 19. The VFD shall integrate into the Building Automation System (BAS) through BacNet interface. This integration shall directly connect each drive to the BAS through a single RS-483 cable, the connection shall be the only means of control and monitoring each drive and shall provide access to the following data:
 - a. Start/stop.
 - b. Change directions (ramp up/ramp down).
 - c. Drive fault (status).
 - d. Drive fault codes.
 - e. Reset drive.
 - f. Percent output (set point).
 - g. Drive speed.
 - h. Drive power.
 - i. Drive temperature.
 - j. kWh.
 - k. Run time.
 - l. The BAS shall have the ability to monitor and command, and to use these points within the full complement of BAS applications such as alarming, trending, totalization and scheduling the same as for all other BAS point data.
- F. Adjustments:
- 1. VFD shall have an adjustable carrier frequency of 2 to 14 kHz through 60 HP and 2 to 4.5 kHz above 60 HP.
 - 2. Three variable-torque V/Hz patterns shall be provided with the ability to select a constant torque start pattern for each of them.
 - 3. Twenty preset speeds shall be provided.
 - 4. Eight acceleration and eight deceleration ramps shall be provided. The shape of these curves shall be adjustable.
 - 5. Four current limit settings shall be provided.
 - 6. If VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset:
 - a. Undervoltage.
 - b. Overvoltage.
 - c. Current limit.
 - d. Inverter overload.
 - e. Motor overload.
 - 7. The number of restart attempts shall be selectable from 0 through 10 and the time between attempts shall be adjustable from 0 through 10 seconds.
- G. Service Conditions:
- 1. Ambient temperature, -10 to 40°C (14 to 104°F).

2. 0 to 95% relative humidity, non-condensing.
 3. Elevation to 3,300 feet without derating.
 4. AC line voltage variation, -10 to +10% of nominal with full output.
 5. No side clearance shall be required for cooling of wall mount units and all power and control wiring shall be done from the bottom.
 6. Drive shall be capable of operating a motor up to 1,000 feet away without derating or field modification.
- H. Accessories:
1. Circuit breaker to serve as means of disconnect.
 2. Provide the necessary line reactors to limit harmonic distortion to 3% THD (voltage) and 8% THD (current) and commutation notch area to 16,400 volt-microsecond with source impedance no more than 0.1 PU of drive size.
 3. Bypass (not required for pumps): Provide a manual bypass consisting of a door interlocked main fused disconnect pad-lockable in the off position, separate drive disconnect, a built-in motor starter and a four position DRIVE/OFF/LINE/TEST switch controlling three contactors. In the DRIVE position, the motor is operated at an adjustable speed from the drive. In the OFF position, the motor and drive are disconnected. In the LINE position, the motor is operated at full speed from the AC power line and power is disconnected from the drive, so that service can be performed. In the TEST position, the motor is operated at full speed from the AC line power. This allows the drive to be given an operational test while continuing to run the motor at full speed in bypass. Customer supplied normally closed dry contact shall be interlocked with the drives safety trip circuitry to stop the motor whether in DRIVE or BYPASS mode in case of an external safety fault.
- I. Warranty: The VFD shall be warranted by the manufacturer for a period of 36 months. The warranty shall include parts, labor, travel costs and living expenses incurred by the manufacturer to provide factory authorized on-site service.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that surface is suitable for controller installation.
- B. Do not install controller until building environment can be maintained within the service conditions required by the manufacturer.

3.2 INSTALLATION

- A. Install controller where indicated, in accordance with manufacturer's written instructions and NEMA ICS 3.1.
- B. Tighten accessible connections and mechanical fasteners after placing controller.
- C. Install fuses in fusible switches.
- D. Select and install overload heater elements in motor controllers to match installed motor characteristics.

- E. Provide engraved plastic nameplates.
- F. Provide neatly typed label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

3.3 FIELD QUALITY CONTROL

- A. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.

3.4 MANUFACTURER'S FIELD SERVICES

- A. Provide start-up commissioning of the variable frequency drives and its optional circuits by a factory certified service technician. Start-up services shall include verification of proper operation and installation of the VFD, its options and its interface wiring to the existing facility management system. Start-up shall include minimum 8 hours of operator training.
- B. Provide a power quality monitoring instrument to record the input current and voltage waveform for each VFD under the entire range of operating speeds under normal operating conditions. Submit data as previously specified.

3.5 ADJUSTING

- A. Make final adjustments to installed drive to assure proper operation of fan system. Obtain performance requirements from installer of driven loads.

3.6 CLEANING

- A. Touch up scratched or marred surfaces to match original finish.

3.7 DEMONSTRATION

- A. Demonstrate operation of controllers in automatic and manual modes.

END OF SECTION 230514