

SECTION 16269

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section

1.2 SUMMARY

- A. This Section includes solid-state, PWM, VFDs for speed control of three-phase, squirrel-cage induction motors

1.3 DEFINITIONS

- A. BMS: Building management system
- B. IGBT: Integrated gate bipolar transistor
- C. LAN: Local area network
- D. PID: Control action, proportional plus integral plus derivative
- E. PWM: Pulse-width modulated
- F. VFD: Variable frequency drive

1.4 SUBMITTALS

- A. Product Data: For each type of VFD. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes
 - 1. Wiring diagrams: Power, signal, and control wiring for VFDs. Provide schematic wiring diagram for each type of VFD, and include coordination with facility SCADA system PLC I/O design affecting each VFD
- B. Operation and Maintenance Data: For VFDs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01740 include the following
 - 1. Routine maintenance requirements for VFDs and all installed components
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices

- C. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs
- B. Source Limitations: Obtain VFDs of a single type through one source from a single manufacturer
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use
- D. Comply with NFPA 70

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver VFDs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated
- B. Store VFDs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFDs from exposure to dirt, fumes, water, corrosive substances, and physical damage
- C. If stored in areas subject to weather, cover VFDs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
 - 1. Ambient temperature: 0 to 40 deg C
 - a. VFDs located in the Pumping and Disinfection Building require ambient temperature rating of 0 to 50 deg C as indicated on the Drawings
 - b. Provide additional features and cooling methods as described on the Drawings and otherwise required for proper equipment operation
 - 2. Humidity: Less than 90 percent (noncondensing)
 - 3. Altitude: Not exceeding 6000 feet

1.8 COORDINATION

- A. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 03300
- C. Coordinate features of VFDs, installed units, and accessory devices with pilot devices and control circuits to which they connect. Coordinate VFD control system design, including programming and auxiliary relays and control devices, with design of associated facility SCADA system PLC I/O and programming and as indicated on the Drawings
- D. Coordinate features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load

1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents
 - 1. Spare fuses: Furnish one spare for every five installed, but no fewer than one set of three of each type and rating
 - 2. Indicating lights: Two of each type installed

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group, "PowerFlex 700" series VFDs

2.2 VARIABLE FREQUENCY DRIVES

- A. Description: NEMA ICS 2, IGBT, PWM, VFD; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency
 - 1. Provide unit suitable for operation for intended motor as defined by NEMA MG 1

- B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection
- C. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range
- D. Unit Operating Requirements
 - 1. Input ac voltage tolerance of 380 to 500 V, plus or minus 10 percent
 - 2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent
 - 3. Minimum efficiency: 96 percent at 60 Hz, full load
 - 4. Minimum displacement primary-side power factor: 96 percent
 - 5. Overload capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds
 - 6. Starting torque: 100 percent of rated torque or as indicated
 - 7. Speed regulation: Plus or minus 1 percent
- E. Isolated control interface to allow controller to follow control signal over an 11:1 speed range
 - 1. Electrical signal: 4 to 20 mA at 24 V
- F. Internal Adjustability Capabilities
 - 1. Minimum speed: 5 to 25 percent of maximum rpm
 - 2. Maximum speed: 80 to 100 percent of maximum rpm
 - 3. Acceleration: 2 to a minimum of 22 seconds
 - 4. Deceleration: 2 to a minimum of 22 seconds
 - 5. Current limit: 50 to a minimum of 110 percent of maximum rating
- G. Self-Protection and Reliability Features
 - 1. Input transient protection by means of surge suppressors
 - 2. Under and overvoltage trips; inverter overtemperature, overload, and overcurrent trips
 - 3. Motor overload relay: Adjustable and capable of NEMA ICS 2, Class 10 performance.
 - 4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 - 5. Instantaneous line-to-line and line-to-ground overcurrent trips
 - 6. Loss-of-phase protection
 - 7. Reverse-phase protection
 - 8. Short-circuit protection
 - 9. Motor overtemperature fault
- H. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load

- I. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped
- J. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds
- K. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds
- L. Harmonic Mitigation Devices
 - 1. 3% AC Line Reactors, factory wired in drive enclosure for 1-100HP @ 460 VAC, VT
 - 2. Broadband low-pass harmonic filters, factory wired in drive enclosure for 125 - 200 HP @ 460 VAC, VT
 - 3. 18-pulse front-end, factory wired in drive enclosure for 250 - 400 HP @ 460 VAC, VT
- M. Status Lights: Door-mounted LED indicators shall indicate the following conditions
 - 1. Power on
 - 2. Run
 - 3. Overvoltage
 - 4. Line fault
 - 5. Overcurrent
 - 6. External fault
- N. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter
- O. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters
 - 1. Output frequency (Hz)
 - 2. Motor speed (rpm)
 - 3. Motor status (running, stop, fault)
 - 4. Motor current (amperes)
 - 5. Motor torque (percent)
 - 6. Fault or alarming status (code)
 - 7. PID feedback signal (percent)
 - 8. DC-link voltage (VDC)
 - 9. Setpoint frequency (Hz)
 - 10. Motor output voltage (V)

P. Control Signal Interface

1. Electric input signal interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs
2. Remote signal inputs: Capability to accept any of the following speed-setting input signals from the facility SCADA system or other control systems:
 - a. 0 to 10-V dc
 - b. 0-20 or 4-20 mA
 - c. Potentiometer using up/down digital inputs
 - d. Fixed frequencies using digital inputs
 - e. RS485
 - f. Keypad display for local hand operation
3. Output signal interface
 - a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following
 - 1) Output frequency (Hz)
 - 2) Output current (load)
 - 3) DC-link voltage (VDC)
 - 4) Motor torque (percent)
 - 5) Motor speed (rpm)
 - 6) Setpoint frequency (Hz)
4. Remote indication interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following
 - a. Motor running
 - b. Setpoint speed reached
 - c. Fault and warning indication (overtemperature or overcurrent)
 - d. PID high- or low-speed limits reached

Q. Communications: Provide an RS485 interface allowing VFD to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFD to be programmed remotely. Provide capability for VFD to retain these settings within the nonvolatile memory

R. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load)

S. Integral Disconnecting Means: For individually mounted VFDs, provide NEMA KS 1, fusible switch with lockable handle. VFDs in Motor Control Center's (MCC) shall have unit mounted disconnecting means

T. Isolating Switch: Non-load-break switch arranged to isolate VFD and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode

2.3 ENCLOSURES

- A. Provide enclosures with NEMA type suitable for intended location unless mounted in MCC

2.4 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type
- C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open
- D. Control Relays: Auxiliary and adjustable time-delay relays
- E. Standard Displays
 - 1. Output frequency (Hz)
 - 2. Setpoint frequency (Hz)
 - 3. Motor current (amperes)
 - 4. DC-link voltage (VDC)
 - 5. Motor torque (percent)
 - 6. Motor speed (rpm)
 - 7. Motor output voltage (V)
- F. Historical Logging Information and Displays
 - 1. Real-time clock with current time and date
 - 2. Running log of total power versus time
 - 3. Total run time
 - 4. Fault log, maintaining last four faults with time and date stamp for each

2.5 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested VFDs before shipping

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFDs for compliance with requirements, installation tolerances, and other conditions affecting performance
- B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation

1. Verify VFD motor lead lengths
2. Provide DV/DT filters for VFD where motor lead lengths exceed 100 feet

C. Proceed with installation only after unsatisfactory conditions have been corrected

3.2 APPLICATIONS

A. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load

B. Select horsepower rating of controllers to suit motor controlled

3.3 INSTALLATION

A. Install VFDs on concrete bases where indicated

B. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Section 16491

3.4 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer

3.5 IDENTIFICATION

A. Identify VFDs, components, and control wiring according to Division 16 Section "Electrical Identification"

B. Operating Instructions: Frame printed operating instructions for VFDs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFD units

3.6 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices according to Section 16120

B. Bundle, train, and support wiring in enclosures

C. Connect hand-off-automatic switch and other automatic-control devices where applicable

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position
2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors

3.7 CONNECTIONS

- A. Conduit installation requirements are specified in other Division 16 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties
- B. Ground equipment according to Section 16060

3.8 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows
 - 1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit
 - 2. Test continuity of each circuit
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - 1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment
 - 2. Assist in field testing of equipment including pretesting and adjusting of solid-state controllers
 - 3. Report results in writing

3.9 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges

3.10 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers

END OF SECTION