

SECTION 23 04 10 – ELECTRONIC VARIABLE SPEED DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: The extent of electronic variable speed drive (VSD) work is as scheduled, shown on the Drawings, as indicated by the requirements of this Section, and as specified elsewhere in these Specifications.
- B. Types: The types of electronic variable speed drives required for the project include, but are not limited to variable frequency motor speed controllers.

1.3 STANDARDS:

- A. Products shall be designed, manufactured, tested, and installed in compliance with the following standards, as applicable:
 - 1. NEMA ICS 2 Industrial Control Devices, Controllers and Assemblies.
 - 2. NEMA KS 1 Enclosed Switches.
- B. Each VSD shall comply with the applicable requirements of the latest standards of ANSI and IEEE-519-1981 5% voltage distortion and line notching category. Computations or computer simulations shall be provided with the submittals to confirm compliance. The VSD manufacturer shall supply all necessary items to comply.
- C. VSD design and construction shall comply with all applicable provisions of the National Electric Code.

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- D. **[Each VSD shall comply with Part 15, Subpart J of FCC rules for Class A computing devices in the range of 7 to 30 MHz for conduction. FCC label of compliance shall be displayed on the VSD.]**

1.4 QUALITY ASSURANCE:

- A. Manufacturers: Provide products complying with these specifications and produced by one of the following:
 - 1. ABB.
 - 2. Toshiba.
 - 3. Yaskawa.
- B. Products supplied under this section must be of domestic (USA) origin and manufacture.]
- C. UL Standards: Speed Controllers shall conform to all applicable UL Standards and shall be UL-listed.
- D. Factory Testing: To ensure quality, each VSD shall be subjected to the following factory tests:
 - 1. The integrated circuits shall undergo a 120 hour "burn-in" to test reliability. During the "burn-in" the temperature shall be cycled between 0 and 70°C.
 - 2. The completed unit shall undergo a fully loaded 24 hour "burn-in" while serving a varying induction motor load. Test load shall vary between 50% and 100% of rated HP capacity and shall include a minimum of 12 hours at rated HP.

3. The unit shall be subject to a series of in-plant quality controlled inspections before approval for shipment from manufacturer's facilities.

1.5 SUBMITTALS:

- A. Shop drawing submittals shall include, but not be limited to, the following:
 1. Cut sheets of individual speed controllers with construction, dimensions, weights, ratings, voltage, poles, options, and all associated accessories clearly indicated.
 2. Wiring diagrams for the drive power, bypass, and control sections.
 3. A detailed description of drive operation and adjustable parameters.
 4. A detailed description of factory testing.
 5. Additional information as required in Section 23 01 00.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Store speed controllers 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.
- B. Handle speed controllers carefully to avoid damage to material components, enclosure and finish.

PART 2 - PRODUCTS

2.1 ELECTRONIC VARIABLE SPEED DRIVES:

- A. General: Provide electronic variable speed drives for control of standard or high-efficiency NEMA Design B induction motors on **[air handling units] [, fans] [and pumps]** where specified herein, scheduled, or shown on the Drawings.
- B. Operation: Each variable speed drive shall convert available utility power to adjustable voltage/frequency, 3-phase, ac power for stepless motor control from 25 to 110% of motor 60 Hz speed.
 1. The variable speed drive (VSD) shall produce an adjustable ac voltage/frequency output for complete motor speed control. Speed control shall be stepless throughout the range under a variable torque load on a continuous basis. The VSD shall be automatically controlled by an external control signal.
 2. The VSD maximum output current rating shall be greater than or equal to the motor nameplate full load. The input power factor of the controller shall be 0.95 or greater under all speed and load conditions and the unit shall be rated for 100% operation at full rated current, voltage and frequency.
 3. The VSD shall contain a fused input power disconnect or circuit breaker with door interlock.

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4. **[A dedicated line filter shall be provided at the input of the VSD to limit EMI from interference with vital electrical equipment if required for FCC compliance as specified in Paragraph 2.09/C/3.]**
- C. **Components:** Each controller shall include, but not be limited to an input rectifier, constant voltage dc link, filter, sine-weighted pulse width modulation inverter and accessory sections with each section modularized for ease of troubleshooting. Controller shall be protected with I²T fuses or circuit breakers per the manufacturer's design and specification. All components shall be factory mounted and wired on a dead-front, grounded, free-standing or wall-mounted minimum NEMA 1 enclosure arranged for top or bottom conduit entry. The free-standing enclosure shall be suitable for mounting on a steel platform or on a concrete housekeeping pad.
 1. The controller enclosure shall be provided with the manufacturer's illustrated operating instructions and parts list mounted inside the enclosure door, manual speed control potentiometer, three position mode selector switch (manual-off-auto), "power on" light, diagnostic/frequency display, auxiliary relays, and contacts for interlock and control wiring.
- D. **Features:** VSD features shall include, but not be limited to, the following:
 1. **Input Power:** **[208] [230] [460]** volts ac, 10%, 60 Hz, 1.8 Hz. Input power factor shall be 0.95 or greater from full motor speed to zero speed for any motor load.
 2. **Output Power:** Three phase, 0-**[460] [208] [230]** volts, 2-60 Hz.
 3. **Ambient Temperatures:** Operating: 0°C to 40°C (32°F to 104°F). Storage: -20°C to 60°C (-4°F to 140°F).
 4. **Frequency Stability:** Output frequency will be held to 0.1% of maximum frequency regardless of load, 10% input voltage change or temperature changes within the ambient specification.
 5. **Disconnect:** Locking type input disconnect switch with external operating handle.
 6. **Bypass:** Manual bypass which isolates the drive from the circuit and allows motor operation at full across-the-line speed. Bypass shall include motor contactor, drive isolation contactors, motor overload protection, fused control power transformer and front panel mounted bypass controls.
 7. **Input Filter:** Input line filter capable of protecting the electronics against transient voltage spikes or notches.
 8. **Current Limit:** To limit output current to 110% of that of the drive rating. The current limit shall be designed to function automatically to prevent overcurrent trip due to momentary overload conditions, allowing the drive to continue operation.
 9. **Instantaneous Overcurrent Trip:** To safely limit the output current in under 50 microseconds due to short circuit or severe overload conditions.
 10. **Undervoltage Trip:** To protect the drive due to non-momentary power or phase loss. The undervoltage trip will activate automatically when line voltage drops 15% below rated input voltage.
 11. **Overvoltage Trip:** To protect the drive due to voltage levels in excess of its rating. The overvoltage trip will activate automatically when the inverter bus in the controller exceeds 950 volts dc.
 12. **Ground Fault Protection:** Fuseless electronic power protection for ground fault protection. Isolation transformers for ground fault protection are not acceptable. Ground fault shall not cause fuses to open.
 13. **Overload Protection:** Electronic output overload protection shall be provided to eliminate the use of bimetallic overloads. The drive shall not be phase sequence sensitive. The overload protection shall also protect the motor when it is operated at full speed in the bypass mode.

14. Overtemperature Trip: To protect the drive from elevated temperatures in excess of its rating. An indicating light which begins flashing with 10°C of the trip point will be provided to alert the operator to the increasing temperature condition. When the overtemperature trip point is reached, this light will be continuously illuminated.
15. Automatic Reset/Restart: The drive shall be equipped such that a trip condition resulting from overcurrent, undervoltage, overvoltage or overtemperature shall be automatically reset, and the drive shall automatically restart upon removal, or correction of the causative condition. The number of reset/restart attempts for undervoltage, overvoltage, overtemperature and overcurrent shall be limited to five. If, in five attempts, a reset/restart is not successful, the drive shall shut down safely, requiring a manual restart. If, within five attempts, a successful reset/restart occurs, the Auto Reset/ Restart circuit will reset the attempts counted to zero after approximately 10 minutes of continuous operation.
16. Power Interruption: In the event that an input or output power contactor is opened or closed while the drive is activated, no damage to the drive shall result.
17. Short Circuit Protection: In the event of a phase-to-phase short circuit the drive shall be designed to shut down safely without component failure.
18. Sustained Power Loss: In the event of a sustained power loss, the drive shall be designed to shut down safely without component failure. Upon return of power, the system shall be designed to automatically return to normal operation.
19. Momentary Power Loss: In the event of a momentary power loss, the drive shall be designed to ride-through a power interruption up to five cycles and shut down safely without component failure. Upon a more extended momentary power loss, the system shall be designed to automatically return to normal operation upon return of power.
20. Stand Alone Operation: To facilitate start-up troubleshooting, the drive shall be designed to operate without a motor or any other equipment connected to the drive output.
21. Start/Stop Control: The drive may be started or stopped by any one of the following:
 - a. A contact closure rated 50 ma, 115 volt ac minimum.
 - b. Use of a motor starter or contactor in the input power line.
 - c. The speed control signal dropping below or rising above minimum.
 - d. An external 115 volt ac signal.
 - e. Operation of momentary start/stop switch or pushbuttons. The drive shall include built-in holding contacts for this purpose.
22. Speed Control: The drive will adjust the output frequency in proportion to a [0-5 volt dc Analog] [0-10 volt dc Analog] [4-20 ma dc Analog] [3-15 psig Pneumatic] [135 Ohm Potentiometer] [5000 Ohm Potentiometer] input.
23. Minimum and Maximum Speed Control: Adjustable minimum and maximum speed potentiometers for all speed signals. Minimum range shall be 0-80%, field set at 40%. Maximum range shall be 100-0%, field set at 100%.
24. Signal Gain and Offset: Adjustable signal gain (1:1 to 10:1 range) and offset (0-50% of input signal for all speed signals).
25. Inverted Signal: Inverted speed signal selector switch to invert the response to input speed signal.
26. Automatic Reversing: Reversing terminals to automatically reverse the rotation of the motor(s) shall be available for customer use if so desired. When a contact closure is made across these terminals, the motor shall decelerate from its operating speed to zero at the preset deceleration rate. Upon reaching zero, it shall reverse direction and accelerate to the set speed at the present acceleration rate.

27. Adjustable Accel/Decel: Independently adjustable acceleration and deceleration time potentiometers from 30-300 seconds, field set at 90 seconds.
28. Control Isolation: Low voltage logic and 115 volt control circuits shall be electrically isolated from the power circuits. Signal circuit common shall be grounded.
29. Control Adjustments: All control adjustments shall be made without the necessity of an extender board or specialized meters, and from front accessible controls.
30. Diagnostics: A diagnostic fault detection center shall be integral to each VSD, providing an indication of the following fault conditions:
 - a. External fault.
 - b. Processor line fault.
 - c. Low ac line voltage.
 - d. High ac line voltage.
 - e. Current overload.
 - f. High dc bus voltage.
 - g. VSD output fault.
31. Status Lights: Status lights for indications of conditions described in Items 1 through 5 shall be provided. An SPDT contact for remote indication of Items 2 through 5 shall be provided. Additionally, status lights to show "Power On", "Zero Speed", and "Drive Enabled" shall be provided. All status lights shall be self-contained in the front panel of the unit and shall be duplicated for ease of troubleshooting on the inside of the unit. Status lights shall be red, light-emitting diode type for high visibility and reliability.
32. Indicating Lights:
 - a. Power On: Lights any time input power is applied to the drive.
 - b. Zero Speed: Illuminates whenever the drive is at zero frequency.
 - c. Enabled: Lights to indicate that the drive has a start command.
 - d. Over Temperature: Begins flashing when the internal temperature of the drive is within 10°C of overheating. Upon reaching the overtemperature trip point, the light is continuously illuminated.
 - e. Current Limit: Indicates that the Accel, Decel or Run Limit circuit is in operation.
 - f. Undervoltage: Indicates that an undervoltage trip has occurred.
 - g. Overvoltage: Indicates that an overvoltage trip has occurred.
 - h. Overcurrent: Indicates that the current rating of the drive has been exceeded and the overcurrent trip circuit has been activated.
33. External Alarm Contacts: A single pole, double throw contact rated 115 volt ac, 28 volt dc, 1 amp resistive, shall be available for external monitoring. Contact will change state when any trip condition has occurred.
34. Speed Reference Signal: A 0 to 5 volt dc signal shall be provided for customer use. This 0 to 5 volt dc signal shall vary in direct proportion to the drive speed.
35. User Interface: The VSD shall have the following door mounted user interface devices:
 - a. "Power On" light.
 - b. Hand/Off/Auto (or equivalent) selector switch.
 - c. Manual speed potentiometer.

d. Digital Readout Frequency Meter/Diagnostic Display.

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36. **Cooling:** The VSD shall be convection-cooled. Units requiring fan cooling are not acceptable. The unit shall have high temperature protection.]
37. **Control Power:** A 115 volt ac, control power shall be available for customer use whenever drive input power is applied.
38. **External Safeties:** Fire alarm interface, safety and temperature control interlock terminals with door mounted "external fault" light.

E. System Operation:

1. Selector switch in the "off" position - the controller run circuit will be open and the system will not operate.
2. Selector switch in the "manual" position - the speeds of the motor will be controlled by the manual speed potentiometer.
3. Selector switch in the "auto" position - operation will be via the external control input signal with the output speed proportional to the input signal.

PART 3 - EXECUTION

3.1 INSTALLATION OF ELECTRONIC VARIABLE SPEED DRIVES:

- A. **General:** Install electronic variable speed drives where shown, in accordance with the manufacturer's written instructions, the applicable requirements of the NEC and the NECA's "Standard of Installation", and recognized industry practices to ensure that products serve the intended function.
- B. **Supports:** Provide all electronic variable speed drives with galvanized angle or other suitable supports where mounting on wall or other rigid surface is impractical. Drives shall not be supported by conduit alone. Where drives are mounted on equipment served, the drive shall not inhibit removal of any service panels or interfere with any required access areas. All drives shall be installed plumb and aligned in the plane of the wall in/on which they are installed.
- C. **Coordination:** The Division 23 Contractor shall coordinate electronic variable speed drive selection and installation including, but not limited to, the following:
 1. Coordinate power wiring to electronic variable speed drives and served motors with the Division 16 Contractor.
 2. Coordinate selection of variable speed drives and served motors to insure compatibility.
 3. Coordinate variable speed drive control interface with controls and sequence of operation specified in **[Section 23 06 00, "Building Controls"] [Division 23]**.

3.2 START-UP/TESTING:

- A. **Pre-energization Check:** The Division 26 Contractor shall check electronic variable speed drive power wiring for continuity of circuits and for short circuits.
- B. **Start-up Services:** A representative of the variable speed drive manufacturer shall provide start-up services for each drive including, but not limited to, the following:
 1. Check out of drive control and power wiring.
 2. Start-up drive and demonstrate proper manual, automatic, and bypass operation.
 3. Adjust variable speed drive overload protection and other adjustable parameters to suit project requirements.
- C. **Motor/Controller Coordination Documentation:** Provide motor/controller coordination documents including, but not limited to, the following information in the operation and maintenance manuals.

1. Motor size in horsepower.
 2. Motor full load amps.
 3. Motor efficiency.
 4. Motor service factor.
 5. Size and manufacturer's catalog number of electronic variable speed drives.
 6. Setting of electronic variable speed drive overload protection and other adjustable parameters.
- D. Motor Rotation: Verify that motor rotation is correct as connected. Where rotation must be changed, the Division 26 Contractor shall reconnect phase conductors to motor leads at motor junction box.

3.3 TRAINING:

- A. General: A representative of the variable speed drive manufacturers shall provide for and present to the Owner, at no cost, a training and troubleshooting course at the owner's location. This course shall be comprised of 2 days of classroom instruction for 4 hours per day complete with visual aids, documentation, circuit diagrams and hands-on training. This course is not to be construed as a sales meeting, but rather as a school to familiarize the owner with the care, troubleshooting, and servicing of the variable speed drives. The manufacturer's representative shall provide a list of recommended spare parts.

3.4 IDENTIFICATION:

- A. Refer to Section 23 03 00 for painting and nameplate requirements for all electronic variable speed drives.
- B. Each electronic variable speed drive shall have an internal wiring diagram on the inside of the drive cover and shall be labeled inside the cover to indicate the type, ampacity and horsepower rating of the unit.

END OF SECTION 23 04 10