

SECTION 230514 – VARIABLE SPEED CONTROLLERS

PART 1 - GENERAL

1.1. SUMMARY

- A. This section includes solid-state, pulse-width modulated, variable speed motor controllers for three-phase, squirrel-cage induction motors.

1.2. SUBMITTALS

A. Product Submittals:

- 1. Product Data: For each type of variable speed controller, 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.

B. Close-Out Submittals:

- 1. Operation and Maintenance Data: For variable speed controllers, all installed devices, and components to include in emergency, operation, and maintenance manuals.
  - a. Routine maintenance requirements for variable speed controllers and all installed components.
  - b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
- 2. 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.
- 3. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.3. 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 variable speed controllers of a single type through one source from a single manufacturer.
  - 1. Exceptions: Variable speed controllers that are factory-mounted to HVAC equipment, such as chillers and cooling towers, and branded by the equipment manufacturer may be provided by the equipment manufacturer.
- C. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.
- D. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.
- E. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

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- F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for variable speed controllers minimum clearances between the controllers and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

### 1.4. DELIVERY, STORAGE, AND HANDLING

- A. Deliver variable speed controllers in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.
- B. Store variable speed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

### 1.5. PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without de-rating, under the following conditions, unless otherwise indicated:
  - 1. Ambient Temperature: 32 to 105 deg F.
  - 2. Humidity: Less than 90 percent (non-condensing).
  - 3. Altitude: Not exceeding 3300 feet.
- B. NEMA-rated enclosures for the installed environment. Refer to Section 230511.

### 1.6. COORDINATION

- A. Coordinate layout and installation of variable speed controllers 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 installation of roof curbs, equipment supports, and roof penetrations.
- C. Coordinate features of variable speed controllers, installed units, and accessory devices with pilot devices and control circuits to which they connect.
- D. Coordinate features, accessories, and functions of each variable speed controller and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

### 1.7. WARRANTY

- A. Special Warranty: Manufacturer's complete parts and labor warranty for 3-years from the date of Owner Acceptance.

### 1.8. 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: One set of three for each variable speed controller.
  - 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. ABB.
  - 2. Danfoss.
  - 3. Yaskawa.

2.2. VARIABLE FREQUENCY CONTROLLERS

- A. Description: NEMA 2, integrated-gate bipolar transistor (IGBT), pulse-width modulated (PWM), variable frequency controller 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. Provide unit suitable for premium motor efficiency operation as defined by NEMA MG 1.
  - 1. Provide 6, 12 or 18-pulse drives as needed to meet the harmonic distortion limits.
- 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 66 Hz, with torque constant as speed changes.
- D. Unit Operating Requirements:
  - 1. Input ac voltage tolerance of 208 V, plus or minus 5 percent; 380 to 500 V, plus or minus 10 percent; and 525 to 575 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 with an electrical signal of 4 to 20 mA at 24V.
- 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.
  - 6. Self-Protection and Reliability Features:

7. Input transient protection by means of surge suppressors.
  8. Under and over-voltage trips; inverter over-temperature, overload, and overcurrent trips.
  9. Motor Overload Relay: Adjustable and capable of NEMA 2, Class 20 performance.
  10. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
  11. Instantaneous line-to-line and line-to-ground overcurrent trips.
  12. Loss-of-phase protection.
  13. Reverse-phase protection.
  14. Short-circuit protection.
  15. Motor over-temperature fault.
- G. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.
- 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 auto-speed 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. Input Line Conditioning: 5% Line Reactor.
- M. VFC Output Filtering: Load reactors (dV/dt filters) for distances greater than 50 feet between drive and load.
- N. 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.
- O. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.
- P. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

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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. Set-point frequency (Hz).
10. Motor output voltage (V).

Q. 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 building automation system (BAS) 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: Minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
  - a. Output frequency (Hz).
  - b. Output current (load).
  - c. DC-link voltage (VDC).
  - d. Motor torque (percent).
  - e. Motor speed (rpm).
  - f. Set-point 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. Set-point speed reached.

- c. Fault and warning indication (over-temperature or overcurrent).
  - d. PID high- or low-speed limits reached.
- R. Communications: Provide an RS485 interface allowing variable frequency controller to be used with an external system within a multi-drop local area network (LAN) configuration. Interface shall allow all parameter settings of variable frequency controllers to be programmed via building automation system (BAS) control. Provide capability for variable frequency controllers to retain these settings within the nonvolatile memory.
- 1. BAS Interface: Factory-installed hardware and software to enable the building automation system (BAS) to monitor, control and display unit status and alarms. BACnet communication interface with the BAS shall enable the BAS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BAS.
- S. 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).
- T. Integral Disconnecting Means: Door interlocked, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 65,000A.
- U. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

### 2.3. ENCLOSURES

- A. Provide NEMA-rated enclosure appropriate for the installed environment. Refer to Section 230511 for more information.

### 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: Door mounted display shall include:
  - 1. Output frequency (Hz).
  - 2. Set-point frequency (Hz).
  - 3. Motor current (amperes).
  - 4. DC-link voltage (VDC).
  - 5. Motor torque (percent).
  - 6. Motor speed (rpm).
  - 7. Motor output voltage (V).

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- 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.

### PART 3 - EXECUTION

#### 3.1. EXAMINATION

- A. Examine areas, surfaces, and substrates to receive variable speed controllers 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 variable speed controllers installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2. APPLICATIONS

- A. Select features of each variable speed controller 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.
- C. Select amperage rating of controllers to suit multiple motor applications.
- D. Variable speed drives shall be furnished for each motor. Do not operate more than one motor on a single variable speed drive unless otherwise noted.

#### 3.3. INSTALLATION

- A. Anchor each variable speed controller assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.
- B. Comply with mounting and anchoring requirements specified in Division 26.
- C. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26.
- D. Seal interior electronics in plastic wrap to protect from dirt during installation. Remove plastic wrap when complete. Cover enclosure vents with MERV-5 filter media prior to using VFD's during construction. Keep VFD's clean. Vacuum dirt and metal shavings from inside and outside of VFD enclosure.

#### 3.4. IDENTIFICATION

- A. Identify variable speed controllers, components, and control wiring according to Section 230553.

#### 3.5. CONTROL WIRING INSTALLATION

- A. Install wiring between variable speed controllers and remote devices according to Division 26.

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- 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.

### 3.6. CONNECTIONS

- A. Conduit installation requirements are specified in Division 26. Drawings indicate general arrangement of conduit, fittings, and specialties.
- B. Ground equipment according to Division 26.
- C. VFD Cable:
  - 1. Provide Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277. Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket. Extra-flexible stranded for all sizes. Armoring is required for cable not installed in conduit.

### 3.7. FIELD QUALITY CONTROL

- A. Factory-trained technician shall perform start-up.
  - 1. Technician shall utilize manufacturer's software with laptop to upload parameters in compliance with manufacturer's warranty.
  - 2. Start-ups shall be witnessed by the Owner and performed prior to TAB.
- B. Perform the following field tests and inspections and prepare test reports:
  - 1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

### 3.8. ADJUSTING

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

### 3.9. 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 230514