

**SECTION 262923**  
**VARIABLE-FREQUENCY MOTOR CONTROLLERS**

**PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Variable-frequency motor controllers for low-voltage (600 V and less) AC motor applications.
- B. Overcurrent protective devices for motor controllers, including overload relays.

**1.02 RELATED REQUIREMENTS**

- A. Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Section 260529 - Hangers and Supports for Electrical Systems.
- C. Section 260553 - Identification for Electrical Systems: Identification products and requirements.

**1.03 REFERENCE STANDARDS**

- A. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code); 2013 (Corrigendum 2019).
- B. IEEE C57.13 - IEEE Standard Requirements for Instrument Transformers; 2016.
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2020.
- E. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts; 2008 (Reaffirmed 2020).
- F. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices; 2017.
- G. NEMA ICS 6 - Industrial Control and Systems: Enclosures; 1993 (Reaffirmed 2016).
- H. NEMA ICS 7 - Industrial Control and Systems: Adjustable-Speed Drives; 2020.
- I. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems; 2014.
- J. NEMA ICS 7.2 - Application Guide for AC Adjustable Speed Drive Systems; 2021.
- K. NEMA ICS 61800-2 - Adjustable Speed Electrical Power Drive Systems, Part 2: General Requirements-Rating Specifications for Low Voltage Adjustable Frequency AC Power Drive Systems; 2005.
- L. NEMA MG 1 - Motors and Generators; 2021.
- M. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems; 2021.
- N. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- O. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.
- P. UL 508A - Industrial Control Panels; Current Edition, Including All Revisions.
- Q. UL 61800-5-1 - Standard for Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements – Electrical, Thermal, and Energy; Current Edition, Including All Revisions.

**1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination:
  - 1. Coordinate work to avoid placement of ductwork, piping, equipment, and other obstructions within dedicated equipment spaces and working clearances required by NFPA 70.
  - 2. Coordinate work to provide motor controllers suitable for use with motors.
  - 3. Coordinate work to provide controllers and associated wiring suitable for interface with control devices.

4. Coordinate arrangement of electrical equipment with dimensions and clearance requirements.
5. Verify with manufacturer that conductor terminations are suitable for use with conductors.
6. Notify Architect of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

#### **1.05 SUBMITTALS**

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for motor controllers, enclosures, overcurrent protective devices, and other installed components and accessories.
  1. Include characteristic trip curves for each type and rating of overcurrent protective device upon request.
- C. Shop Drawings: Indicate dimensions, voltage, controller sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
  1. Include dimensioned plan and elevation views of controllers and adjacent equipment with required clearances indicated.
  2. Include wiring diagrams showing factory and field connections.
  3. Indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series-rated systems.
  4. Include documentation of listed series ratings upon request.
  5. Include documentation demonstrating selective coordination upon request.
  6. Identify mounting conditions required for equipment seismic qualification.
- D. Specimen Warranty: Submit sample of manufacturer's warranty.
- E. Manufacturer's detailed field testing procedures.
- F. Field quality control test reports.
- G. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
  1. Include contact information for entity providing contract maintenance and trouble call-back service.
- H. Project Record Documents: Record actual installed locations of controllers and final equipment settings.
  1. Include nameplate data of actual installed motors and associated overload relay selections and settings.
  2. Motor Circuit Protectors: Include magnetic instantaneous trip settings.
- I. Maintenance Materials: Furnish following for Owner's use in maintenance of project.
  1. See Section 016000 - Product Requirements for additional provisions.
  2. Air Filters: Two of each different type.

#### **1.06 QUALITY ASSURANCE**

- A. Comply with requirements of NFPA 70.
- B. Maintain copy of each referenced document that prescribes execution requirements at project site.
- C. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
- D. Installer Qualifications: Company with minimum three years documented experience with variable-frequency motor control systems of similar size, type, and complexity; manufacturer's authorized installer.
- E. Product Listing Organization Qualifications: Organization recognized by OSHA as Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

**1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Store in clean, dry space. Maintain factory wrapping or provide additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to internal components, enclosure, and finish.

**1.08 FIELD CONDITIONS**

- A. Maintain field conditions within required service conditions during and after installation.

**1.09 WARRANTY**

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Provide minimum 18-month manufacturer warranty covering repair or replacement due to defective materials or workmanship.

**PART 2 PRODUCTS****2.01 MANUFACTURERS**

- A. Variable-Frequency Motor Controllers:
  - 1. ABB: [www.new.abb.com/#sle](http://www.new.abb.com/#sle).

**2.02 VARIABLE-FREQUENCY MOTOR CONTROLLERS**

- A. Provide variable-frequency motor control system consisting of required controller assemblies, operator interfaces, control power transformers, instrumentation and control wiring, sensors, accessories, system programming, etc. as necessary for complete operating system.
- B. Provide products listed, classified, and labeled as suitable for purpose intended.
- C. Variable-Frequency Motor Controller:
  - 1. Configuration: Packaged controller, nonbypass.
  - 2. Power Conversion System: Diode-based, 6-pulse type.
  - 3. Control Method: Vector; open-loop, without feedback.
  - 4. Input/Output Connections: Two.
  - 5. Features:
    - a. Braking chopper/resistor.
    - b. Safety interlock.
- D. Controller Assemblies: Comply with NEMA ICS 7, NEMA ICS 7.1, and NEMA ICS 61800-2; list and label as complying with UL 61800-5-1 or UL 508A as applicable.
- E. Provide controllers selected for actual installed motors and coupled mechanical loads in accordance with NEMA ICS 7.2, NEMA MG 1 Part 30, and recommendations of manufacturers of both controller and load, where not in conflict with specified requirements; considerations include, but are not limited to:
  - 1. Motor type (e.g., induction, reluctance, and permanent magnet); consider NEMA MG 1 design letter or inverter duty rating for induction motors.
  - 2. Motor load type (e.g., constant torque, variable torque, and constant horsepower); consider duty cycle, impact loads, and high inertia loads.
  - 3. Motor nameplate data.
  - 4. Requirements for speed control range, speed regulation, and braking.
  - 5. Motor suitability for bypass starting method, where applicable.
- F. Devices on Load Side of Controller: Suitable for application across full controller output frequency range.
- G. Operating Requirements:
  - 1. Input Voltage Tolerance: Plus/minus 10 percent of nominal.
  - 2. Input Frequency Tolerance: Plus/minus 5 percent of nominal.
  - 3. Efficiency: Minimum of 96 percent at full speed and load.
  - 4. Input Displacement Power Factor: Minimum of 0.96 throughout speed and load range.
  - 5. Overload Rating:

- a. Variable Torque Loads: Minimum of 110 percent of nominal for 60 seconds.
  - b. Constant Torque Loads: Minimum of 150 percent of nominal for 60 seconds.
- H. Power Conversion System: Microprocessor-based, pulse width modulation type.
- I. Control System:
  - 1. Provide microprocessor-based control system for automatic control, monitoring, and protection of motors. Include sensors, wiring, and connections necessary for functions and status/alarm indications specified.
  - 2. Provide integral operator interface for controller programming, display of status/alarm indications, fault reset, and local control functions including motor run/stop, motor forward/reverse selection, motor speed increase/decrease, and local/remote control selection.
  - 3. Control Functions:
    - a. Control Method: Selectable vector and scalar/volts per hertz unless otherwise indicated.
      - 1) Scalar/Volts per Hertz Control: Provide IR compensation for improved low-speed torque.
      - 2) Vector Control: Provide selectable autotuning function.
    - b. Adjustable acceleration and deceleration time; linear and S-curve ramps; selectable coast to stop.
    - c. Selectable braking control; DC injection or flux braking.
    - d. Adjustable minimum/maximum speed limits.
    - e. Adjustable pulse width modulation switching carrier frequency.
    - f. Adjustable motor slip compensation.
    - g. Selectable autorestart after noncritical fault; programmable number of time delay between restart attempts.
  - 4. Status Indications:
    - a. Motor run/stop status.
    - b. Motor forward/reverse status.
    - c. Local/remote control status.
    - d. Output voltage.
    - e. Output current.
    - f. Output frequency.
    - g. DC bus voltage.
    - h. Motor speed.
  - 5. Protective Functions/Alarm Indications:
    - a. Overcurrent.
    - b. Motor overload.
    - c. Undervoltage.
    - d. Overvoltage.
    - e. Controller overtemperature.
    - f. Input/output phase loss.
    - g. Output short circuit protection.
    - h. Output ground fault protection.
  - 6. Inputs:
    - a. Digital Input(s): Three.
    - b. Analog Input(s): Two.
  - 7. Outputs:
    - a. Analog Output(s): One.
    - b. Relay Output(s): Two.
  - 8. Communications: Compatible with connected systems. Provide accessories necessary for proper interface.
    - a. Ethernet Communications: Support for Modbus TCP protocol.
  - 9. Features:
    - a. Password-protected security access.

- b. Event log.
- J. Power Conditioning/Filtering:
  - 1. Provide DC link choke or input/line reactor for each controller unless otherwise indicated or required.
  - 2. Reactor Impedance: 3 percent, unless otherwise indicated or required.
- K. Packaged Controllers: Controllers factory-mounted in separate enclosure with externally operable disconnect and specified accessories.
  - 1. Disconnects: Circuit breaker or disconnect switch type.
    - a. Disconnect Switches: Fusible type or nonfusible type with separate input fuses.
    - b. Provide externally operable handle with means for locking in OFF position. Provide safety interlock to prevent opening cover with disconnect in ON position with capability of overriding interlock for testing purposes.
    - c. Provide auxiliary interlock for disconnection of external control power sources where applicable.
  - 2. Provide door-mounted remote operator interface.
- L. Service Conditions:
  - 1. Provide controllers and associated components suitable for operation under following service conditions without derating:
    - a. Altitude: Less than 3,300 feet (1,000 m).
    - b. Ambient Temperature: Between 32 degrees F (0 degrees C) and 104 degrees F (40 degrees C).
  - 2. Provide controllers and associated components suitable for operation at indicated ratings under service conditions at installed location.
- M. Short Circuit Current Rating:
  - 1. Provide line/input reactors where specified by manufacturer for required short circuit current rating.
- N. Conductor Terminations: Suitable for use with conductors to be installed.
- O. Enclosures:
  - 1. Comply with NEMA ICS 6.
  - 2. NEMA 250 Environment Type or Equivalent IEC 60529 Rating: Unless otherwise indicated, as specified for following installation locations:
  - 3. Finish: Manufacturer's standard unless otherwise indicated.
  - 4. Cooling: Forced air or natural convection as determined by manufacturer.

### 2.03 OVERCURRENT PROTECTIVE DEVICES

- A. Overload Relays:
  - 1. Provide overload relays and, where applicable, associated current elements/heaters selected for actual installed motor nameplate data, in accordance with manufacturer's recommendations and NFPA 70; include consideration for motor service factor and ambient temperature correction, where applicable.
  - 2. Comply with NEMA ICS 2.
  - 3. Inverse-Time Trip Class Rating: Class 20 unless otherwise indicated or required.
  - 4. Trip-free operation.
  - 5. Visible trip indication.
  - 6. Resettable.
    - a. Employ manual reset unless otherwise indicated.
    - b. Do not employ automatic reset with two-wire control.
  - 7. Solid State Overload Relays:
    - a. Adjustable full load current.
    - b. Phase loss protection.
    - c. Phase imbalance protection.
    - d. Ambient temperature insensitive.
    - e. Thermal memory.

- f. Trip test function.
  - g. Provide isolated alarm contact.
- B. Circuit Breakers:
  - 1. Molded Case Circuit Breakers:
    - a. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers; listed and labeled as complying with UL 489; ratings, configurations, and features as indicated or as required.
    - b. Interrupting Capacity:
      - 1) Provide circuit breakers with interrupting capacity as required to provide short circuit current rating indicated, but not less than specified minimum requirements.
      - 2) Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than short circuit current rating indicated.

## **2.04 ACCESSORIES**

- A. Auxiliary Contacts:
  - 1. Comply with NEMA ICS 5.
  - 2. Provide number and type of contacts indicated or required to perform necessary functions, including holding (seal-in) circuit and interlocking, plus one normally open (NO) and one normally closed (NC) spare contact for each bypass motor starter, minimum.

## **2.05 SOURCE QUALITY CONTROL**

- A. See Section 014000 - Quality Requirements for additional requirements.
- B. Factory test controllers in accordance with NEMA ICS 61800-2.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that ratings of controllers are consistent with indicated requirements.
- C. Verify that mounting surfaces are ready to accept controllers.
- D. Verify that conditions are satisfactory for installation prior to starting work.

### **3.02 INSTALLATION**

- A. Install products in accordance with manufacturer's instructions.
- B. Install controllers in accordance with NECA 1 (general workmanship).
- C. Install in accordance with NEMA ICS 7.1 and manufacturer's instructions.
- D. Do not exceed manufacturer's recommended maximum cable length between controller and motor.
- E. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- F. Provide required support and attachment in accordance with Section 260529.
- G. Install controllers plumb and level.
- H. Provide grounding and bonding in accordance with Section 260526.
- I. Install field-installed devices, components, and accessories.
- J. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- K. Set field-adjustable settings of controllers and associated components according to installed motor requirements, in accordance with recommendations of manufacturers of controller and load.

### **3.03 FIELD QUALITY CONTROL**

- A. Inspect and test in accordance with NETA ATS, except Section 4.

- B. Perform inspections and tests listed in NETA ATS, Section 7.17. Insulation-resistance test on control wiring listed as optional is not required.
- C. Correct deficiencies and replace damaged or defective controllers or associated components.

### **3.04 ADJUSTING**

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

### **3.05 CLEANING**

- A. Clean dirt and debris from controller enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

### **3.06 CLOSEOUT ACTIVITIES**

- A. See Section 017800 - Closeout Submittals for closeout submittals.
- B. See Section 017900 - Demonstration and Training for additional requirements.
- C. Demonstration: Demonstrate proper operation of controllers to Owner, and correct deficiencies or make adjustments as directed.
- D. Training: Train Owner's personnel on operation, adjustment, and maintenance of controllers and associated devices.
  - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
  - 2. Provide minimum of two hours of training.
  - 3. Instructor: Manufacturer's authorized representative.
  - 4. Location: At project site.

### **3.07 PROTECTION**

- A. Protect installed controllers from subsequent construction operations.

### **3.08 MAINTENANCE**

- A. See Section 017000 - Execution and Closeout Requirements for additional requirements relating to maintenance service.
- B. Provide trouble call-back service upon notification by Owner:
  - 1. Provide on-site response within 4 hours of notification.
  - 2. Include allowance for call-back service during normal working hours at no extra cost to Owner.
  - 3. Owner will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.

**END OF SECTION 262923**

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