SECTION 26 2923

VARIABLE FREQUENCY DRIVES

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Variable frequency drives, rated less than 600V, for speed control of three-phase, induction motors.

1.2 REFERENCES

A. ANSI/IEEE 399: Standard Practice for Industrial and Commercial Power Systems Analysis

B. NEMA: Application Guide for AC Adjustable Speed Drive Systems

C. NEMA ICS 61800-2: Adjustable Speed Electrical Power Drive Systems

D. NEMA ICS 7.0: Industrial Controls & Systems for Adjustable Speed Drives

E. NEMA ICS 7.1: Standard Standards for Construction and Guide Selection, Installation, and Operation of Adjustable Speed Drive Systems

F. NEMA MG 1: Motors and Generators

G. NETA ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems

H. NFPA 70: National Electrical Code

I. UL 508: Standard for Industrial Control Equipment

J. UL 508C: Standard for Safety for Power Conversion Equipment

1.3 SUBMITTALS

A. Product data: For each type and rating of equipment, include electrical ratings, operating characteristics, manufacturers' technical data on features and functions, enclosures, and furnished accessories. Include product data for each of the following:

1. Variable frequency drive (VFD).

a. List rated capacities and relationship to motor values including voltage, horsepower, rated current, and short-circuit ratings.

B. Bill of materials: Provide detailed list of components.

C. Shop drawings: For each type of unit, indicate the following:

1. Dimensioned plans, elevations, and sections; weights; loads; required clearances; mounting arrangements; components; and location of each field connection.
2. List of installed device and related equipment ratings and features including:

a. Unit type and standard details

b. Enclosure type
c. Nameplate and identification labels
d. Factory settings of installed devices

3. Wiring diagrams: Power, signal, and control wiring.

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and maintenance data: For each type of variable frequency drive and associated components, include in operation and maintenance manuals. In addition to items specified in Division 01 include the following:

1. Detailed operating and programming instructions.
2. Troubleshooting procedures.
3. Detailed spare parts list.
4. Warranty, executed and signed at the time of putting the unit in service.

1.4 QUALITY ASSURANCE

A. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application; listed as a complete assembly.

1. UL label and local testing (where required): As specified in Section 26 0500, Common Work Results for Electrical.

B. Variable frequency drives shall be fully assembled, inspected, and tested at the factory prior to shipment.

C. Provide variable frequency drives from the same manufacturer.

D. Installer qualifications:

1. Staff is authorized and factory-trained by manufacturer. Includes training in electrical safety as required by NFPA 70E and qualified as defined in NEMA PB 2.
2. Maintains a service center location with staff factory-trained by manufacturer in the Baltimore/Washington, DC, metropolitan area.
3. Service available 24 hours a day, seven days a week, 365 days a year.
4. Maintains an adequate stock of manufacturer's genuine or approved parts to service this equipment.
5. Service and maintenance contracts available.

E. Testing agency qualifications: Member company of NETA or a nationally recognized testing laboratory (NRTL).

1. Testing agency's field supervisor: Currently certified by NETA to supervise on-site testing.

F. Comply with referenced standards and listings previously identified including NEMA MG 1, UL 508C, and NFPA 70.

G. Verify motor, drive, and load compatibility. Motors shall be inverter duty rated, per NEMA MG1.

1.5 COORDINATION

A. Ratings and functions of each variable frequency drive unit shall be coordinated with associated motor and connected load including the following:

1. Load requirements such as torque, speed, and horsepower.
2. Motor and power supply characteristics.
3. Control and operational sequences.
4. Ambient, environmental, and physical conditions of installation location.

B. Coordinate layout and installation of drive and associated components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access.

C. Coordinate method and location for mounting equipment including size and location of housekeeping pads and structural channel supports.

D. Coordinate location of underslab and overhead conduit.

E. Coordinate with ATC for proper control and communications functions.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store equipment indoors in clean dry space with uniform temperature to prevent condensation. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.7 PROJECT CONDITIONS

A. Environmental conditions: Variable frequency drive assembly and associated components shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient temperature: 0 to 40 deg C.
2. Relative humidity: 5 to 95 percent, non-condensing.
3. Altitude: Sea level to 3300 feet (1000 m).

B. Special environmental conditions: Where indicated on the drawings, provide equipment with enclosure ratings suitable for the installed space. Enclosure ratings shall comply with NEMA 250 and UL standards.

1.8 WARRANTY

A. Special warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components of drive unit and associated auxiliary components that fail in materials or workmanship within specified warranty period:

1. Warranty period: Five years from date of substantial completion.
2. Warranty shall include all parts and labor.

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. Control power fuses: Six of each type and rating used.
2. Indicating lights: Six of each type installed.
3. Touchup paint: Three containers of paint matching enclosure finish, each 0.5 pint (250mL).

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide products manufactured by ABB, Inc., or comparable product by one of the following:

1. ABB, Inc.
2. Eaton Corporation
3. Trane/Danfoss
4. Yaskawa Electric America, Inc.

2.2 VARIABLE FREQUENCY DRIVES

A. Description: Enclosed variable frequency, alternating-current (AC) motor controller assembly suitable for operation of inverter-duty, Design A and Design B, induction motors as defined by NEMA MG1. The drive shall be designed for variable torque applications.

1. Unit shall be a packaged assembly including power conversion components, disconnecting means, overcurrent and overload protection, bypass, and control components.

B. Equipment ratings and design:

1. Ratings: VFD shall be sized to match the motor load type served. The motor current, voltage, and/or horsepower ratings are scheduled on the drawings. The following drive ratings shall also apply:

a. Input power characteristics: Unit shall be capable of continuous operation under the following conditions.

(1) Voltage variation: Plus 10 percent or minus 15 percent, nominal 208 VAC or 480 VAC.
(2) Frequency variation: Plus or minus 5 percent, 60 Hz.
(3) Power factor (input-primary side): 0.95 minimum.

b. Output power characteristics: 0 to Rated Input Voltage, 3-phase, 0 to 120 Hz.

(1) Current: Drive shall be capable of continuous operation at rated full load motor current.
(2) Power factor (output-secondary side): 0.90 minimum.

c. Minimum efficiency: 95 percent at half speed; 97 percent at rated full speed.
d. Overload capability: 110 percent of the normal duty current rating for 60 seconds, and 130 percent for 2 seconds.
e. Short-circuit current (withstand) rating: Minimum 65 kA, without additional input fuses, or available fault current value determined by short circuit analysis, whichever is greater.
f. Audible noise: Motor and VFD combination noise level shall not be increased more than 2 dBA at 3 feet (1m), compared to motor operation from across-the-line motor control.
g. Output carrier frequency: Unit shall have adjustable frequency switching settings up to 4 kHz without derating the drive output characteristics. Drive selection size may be increased to comply.

©2023 James Posey Associates, Inc. 7753-22

2. Design: Unit shall consist of the following components and characteristics:

    a. Power conversion components: Microprocessor based control.

        (1) Rectifier: Solid state, full-wave, diode-bridge rectifier used to convert AC input power to DC power, with metal-oxide-varistor (MOV) surge protection.

            (a) Provide 6-pulse drives.

        (2) DC bus: DC-bus reactor and capacitor components to minimize reflected harmonics and manage DC power to inverter. Bus shall interface with VFD programmable logic controller, for continuous monitoring and protection of system components, and include short circuit protection and filtering.
        (3) Inverter: Insulated-gate-bipolar-transistor (IGBT) type employing pulse-width-modulated (PWM) technology power supplies for sine-code, AC output waveform.

    b. Standard power conditioning components: Provide the following power conditioning and filter devices.

        (1) Integral, DC link reactor.
        (2) Integral, 3-phase, EMI/RFI filter capable of filtering out radio frequency interference (RFI) in the range of 10 kHz to 30 MHz, and compliant with FCC regulations.
        (3) Output reactor filters on load side of drive for motor protection where motor length is greater than 100 feet (30.5 m).

C. Construction:

1. Enclosure: UL (NEMA 250) Type 12 (indoors), Type 3R (outdoors), and Type 1 (within HVAC units) according to UL 508; or as scheduled on the drawings.

    a. For units located outdoors and subject to direct sun exposure, provide sun shields over front, side and top of enclosures.

2. Completely assembled and tested by the manufacturer. Listed and labeled as a complete assembly under UL 508C.
3. Furnish each unit with a master nameplate, listing standard manufacturer information including voltage, ampacity, frequency, and short-circuit ratings; manufacturer's model and project designations.

D. Drive features:

1. System interface:

    a. Digital display and keypad operator station sealed and located on front of assembly.

        (1) Operator interface shall provide complete programming, program copying, operating, monitoring, and diagnostic capabilities.
        (2) Operator interface shall include menus and selections to display system characteristics such as metering, program parameters, settings, and messages. Standard displays shall include:

            (a) Output frequency (hertz).
            (b) Set-point frequency (hertz).
            (c) Motor current (amperes).

(d) DC-link voltage (volts-dc).
(e) Motor torque (percent).
(f) Motor speed (rpm).
(g) Motor output voltage (volts).
(h) Historical Information: Displays indicating current time and date, total run time, total power versus time log, and fault log.

(3) Keypad shall include Hand-Off-Auto selections in addition to programming and control keys.
(4) Security access: Capable of preventing access by unauthorized personnel and protecting data and system parameters.

b. System input characteristics capable of accepting remote signals from the Building Automation System (BAS) shall include the following:

(1) Minimum of six programmable, multifunction digital inputs.
(2) Minimum of two programmable analog inputs accepting current or voltage signals for speed reference.
(3) Minimum of one external fault input, programmable for normally open or normally closed contact, used for connection of freeze, fire, smoke contacts, or high-pressure limits.

c. System output characteristics including the following:

(1) Minimum of three programmable, multifunction, digital, Form-C type, relay outputs.
(2) Minimum of two programmable analog outputs.
(3) Programmable loss-of-load, Form-C type, relay output dedicated to drive protection under motor failure condition.

2. Building automation system (BAS) interface: Factory-installed or optional card hardware and software package to enable the BAS to monitor, control, and display VFD status, alarms, and energy usage.

a. Network communications: Ethernet based with RS-422/RS-485 communication port.
b. Integral or removable communications card embedded with standard BAS protocols including Johnson Controls, Modbus, Siemens Building Technologies, and BACnet. Additional protocols such as LonWorks, DeviceNet, Ethernet TCP/IP, and Profibus shall be available with the addition of an optional card.

3. Provide separate terminal strip and four auxiliary contacts for connection to remote device providing remote start/stop signals. All interlocks and start/stop contacts shall remain functional whether the drive is in Hand, Auto, or Bypass.
4. Local Communication Port: RS-232 or USB 2.0 for connection of portable computer or peripheral device.
5. Cooling fans: VFD shall incorporate cooling fan system to dissipate heat from assembly to maintain drive temperature control.
6. Control power for drive controls as well as digital inputs and outputs shall be derived from internal power supply or control system power source.

E. Drive functions: The VFD shall include the following functions, either pre-programmed or field-programmed according to project requirements.

1. Minimum of three programmable preset speeds.
2. The ability to automatically reset and restart after an overcurrent, overvoltage, undervoltage, or over-temperature condition; overload fault; loss of phase, or loss of input signal.

3. Capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to programmed set point without drive tripping or component damage.
4. Capable of adjusting acceleration and deceleration ramp control time from 1 to 360 seconds.
5. Equipped with an automatic extended power loss ride-through circuit which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be 12 cycles (200 milliseconds), based on full load and no inertia. Control logic shall incorporate programmable ride-through with minimum one-second (60 cycles).
6. Stop modes shall be field-selectable allowing the VFD to ramp or coast to a stop.

F. Drive and motor protection: Include the following electrical protection and safety features, factory mounted and wired within the VFD enclosure.

1. Input disconnecting means and overcurrent protective device: Integral, NEMA AB1, thermal magnetic, molded-case circuit breaker, with door interlocked, padlockable handle mechanism connected to input line side of drive.

   a. Circuit breaker shall be selected to provide trip-free operation. Breaker trip size and thermal curve shall be selected to allow VFD to operate the motor under continuous running and starting conditions as recommended by the motor manufacturer.
   b. Service personnel shall be able to circumvent the main power disconnect and open the bypass enclosure without disconnecting power. A specific tool and mechanism shall be provided to accomplish this occurrence while meeting code and safety requirements.

2. Transient voltage surge suppression (TVSS): Integral, system to provide three-phase protection against damage from supply voltage surges.
3. Motor and VFD overload and overtemperature protection: NEMA ICS 2, bimetallic thermal, Class 20 or solid-state, overload relay protection monitoring both motor and VFD characteristics. Relay shall be interconnected with motor thermal couple.
4. Protective relays or functions for the following conditions:

   a. Overvoltage
   b. Undervoltage
   c. Phase loss – Equal to ICM 450 phase monitor
   d. Phase reversal
   e. Ground fault

5. Programmable, critical frequency lock-out: Multi-range selection, preventing VFD from operating load continuously at an unstable speed.
6. Control fuses utilized within the drive enclosure shall be 100,000 A current limiting type. Input AC power fusing is not acceptable.

G. Comply with requirements of NEMA ICS 7, NEMA ICS 61800-2, and UL 580C.

2.3 DRIVE CONTROL AND OPERATION

A. VFD shall operate according to the following scenarios:

1. “Hand”: VFD shall start and speed controlled manually through user interface.
2. “Off”: VFD shall stop or disregard start signal.
3. “Auto”: VFD shall start via external contact closure or control signal reference.

B. VFD shall run at programmable preset speed if input reference signal is lost.

2.4 SOURCE QUALITY CONTROL

A. Test and inspect variable frequency drive units and associated controls according to requirements in NEMA ICS 61800-2 and UL 508C.

   1. Perform tests at rated full load to ensure proper operation.
   2. Provide three certified copies of factory test reports.

B. Each drive shall undergo a burn-in test at 100 percent inductive or motor load prior to final testing.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine project submittals for compliance with electrical distribution system requirements outlined on the drawings and in electrical specification sections.

3.2 INSTALLATION

A. Install drive units in locations shown on drawings. Equipment shall not be located further from the equipment it serves than the maximum distance recommended by the drive manufacturer.

B. Install wiring between drive and motor in ferrous metallic conduit, with separate conduits for power input, power output, and control wiring.

   1. Maintain minimum separation between conduits of 3 inches.

C. Service engineers trained and authorized by the variable-frequency drive manufacturer at the service center shall provide start-up service, including physical inspection of drive and connected wiring and final adjustments to meet specified performance requirements.

3.3 IDENTIFICATION

A. Materials: Refer to Section 26 0553 for requirements on identification of electrical systems. Identify units, devices, fuse blocks, relays, controls, and wiring. Identify equipment ratings.

B. Nameplates: Refer to Section 26 0553 for requirements on identification of electrical systems. Provide nameplate for each drive unit and associated components located on front of assembly.

C. Control components mounted within the assembly shall be identified corresponding to designations on manufacturer's drawings using tags and other identification materials.

D. Operating instructions: Provide fabricated frame on side of each unit to house operating instruction manuals.

3.4 FIELD QUALITY CONTROL

A. Test variable frequency drives by operating them in all modes with associated components and motors. Perform tests recommended by manufacturer under supervision of manufacturer's factory-authorized representative. Tests shall include simulation of various building conditions through the BAS, ATC, or DDC control system.

B. Coordinate tests with system balancing of fan and pump equipment.

C. Perform mechanical and visual inspection of equipment installation including verification of wiring and components, connections, enclosures, and auxiliary devices and components.

D. Perform testing in compliance with NETA ATS. Perform manufacturer standard tests including the following:

1. Test insulation resistance and circuit continuity for power and control wiring.
2. Verify voltage values follow nameplate ratings at drive input and output terminals.

E. Correct deficiencies and retest equipment until equipment is operational. Report results and identify corrections in writing. Where necessary, replace damaged and malfunctioning equipment.

F. Record field adjustable settings.

3.5 ADJUSTING

A. Program variable frequency drives for required operations as outlined by the mechanical control sequences.

B. Set field-adjustable elements such as switches, relays, timers, and trip devices as required for proper system operation and coordination with related power and control systems.

3.6 CLEANING

A. Upon completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Clean components internally using methods and materials recommended by the manufacturer.

3.7 SYSTEM STARTUP

A. Perform startup service.

3.8 OPERATING INSTRUCTIONS

A. As specified in Sections 26 0500, provide operating instructions.

END OF SECTION