

SECTION 23 89 00 – 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 REFERENCES

- A. ANSI/NFPA 70 — National Electrical Code.
- B. ANSI C84.1 — Voltage Tolerances for North America.
- C. IEC 68 Part 2-3 — Basic Environmental Testing Procedures Part 2: Tests — Damp Heat.
- D. IEC 146.1 — Semiconductor Converters — General Requirements and Line Commutated Converters Part 1-1: Specifications of Basic Requirements.
- E. IEC 664 — Insulation Coordination for Equipment Within Low-Voltage Systems.
- F. IEC 447 — Man-Machine Interface Actuating Principles.
- G. IEC 439 Part 1 — Low Voltage Switchgear and Control Gear Assemblies.
- H. IEC 947 — Low Voltage Switchgear and Control Gear Components.
- I. IEC 364 — Electrical Installation of Buildings.
- J. IEC 204/NFPA 79 — Electrical Equipment of Industrial Machines/Industrial Machinery.
- K. IEC 106 — Guide for Specifying Environmental Conditions for Equipment Performance Rating.
- L. IEC 529 — Degrees of Protection Provided by Enclosure.
- M. IEC 1000 — Electromagnetic Compatibility.
- N. IEC 721 — Classification of Environmental Conditions.
- O. IEC 255-8 — Overload Relays.
- P. IEC 801-2, -3, -4, -5 — Immunity Tests.
- Q. NEMA ICS 6 — Industrial Control and Systems Enclosures.
- R. NEMA ICS, Part 4 — Overload Relays.
- S. NEMA 250 — Enclosures for Electrical Equipment.
- T. NEMA ICS 2-321 — Electrical Interlocks.

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- U. NEMA ICS7 — Industrial Control and Systems Adjustable Speed Drives.
- V. NEMA ICS 7.1 — Safety Standards for Construction and Guide for Selection Installation and Operation of Adjustable Speed Drives.
- W. UL 50 — UL Standard for Safety Enclosures for Electrical Equipment.
- X. UL 98 — UL Standard for Disconnect Switches.
- Y. L 507 — UL Standard for Safety Electric Fans.
- Z. UL 508 — UL Standard for Safety Industrial Control Equipment.
- AA. UL 508C — UL Standard for Safety Power Conversion Equipment.
- BB. UL 991 — UL Standard for Safety Tests for Safety Related Controls employing Solid-State Devices.
- CC. OSHA 1910.95 — AC Drive Controller Acoustical Noise.
- DD. Conforming to National Safe Transmit Association and International Safe Transmit Association Test for Packages Weighing 100 lbs. or over.

1.3 SUMMARY

- A. This section provides specification requirements for adjustable frequency drives and variable speed drives, herein referred to as AC Drives, for use with NEMA B, design AC motors.
- B. The AC Drive manufacturer shall furnish, field test, adjust, and certify all installed AC Drives for satisfactory operation.
- C. Any exceptions/deviations to this specification shall be indicated in writing and submitted with the quotation.

1.4 SUBMITTALS

- A. Submittal packages including drawings shall be furnished for Engineers approval prior to factory assembly of the AC Drives. These packages shall consist of elementary power and control wiring diagrams on one drawing and enclosure outline drawings. The enclosure drawings shall include front and side views of the enclosures with overall dimensions and weights shown, conduit entrance locations. Standard catalog specification sheets showing voltage, horsepower and maximum current ratings shall be furnished as part of the submittal package.
- B. Submittals for Variable Frequency Drives will require a coordination review by the HVAC Controls manufacturer/installer prior to submission to the Engineer. Refer to Section 23 09 00.

1.5 QUALITY ASSURANCE

- A. The manufacturer of the AC Drive shall be a certified ISO 9002 facility.
- B. The AC Drive and all associated optional equipment shall be UL Listed according to UL 508 C Power Conversion Equipment. As verification, a UL label shall be attached on the inside nameplate of the combination enclosure.

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- C. The AC Drive shall be designed, constructed, and tested in accordance with NEMA, NEC, and IEC standards.
- D. Every power converter shall be tested with an AC induction motor while loaded and temperature cycled within an environment chamber at 40 <C (104 <F).
- E. All pilot devices shall be industrial rated and tested to verify proper operation.

1.6 COORDINATION

- A. Coordinate layout and installation of Adjustable frequency drives 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 features of Adjustable frequency drives, installed units, and accessory devices with pilot devices and control circuits to which they connect.
- C. Coordinate features, accessories, and functions of each drive and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.7 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 not less than one set of each type and rating.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. ABB Power Distribution, Inc.
  - 2. Eaton.
  - 3. Square D.
  - 4. Danfoss.
- B. Alternate control techniques other than pulse width modulated (PWM) are not acceptable.

2.2 GENERAL DESCRIPTION

- A. The AC Drive shall convert the input AC mains power to an adjustable frequency and voltage, as defined in the following sections.
- B. The input power section shall utilize a full wave bridge design incorporating diode rectifiers. The diode rectifiers shall convert fixed voltage and frequency, AC line power to fixed DC voltage. This power section shall be insensitive to phase rotation of the AC line.

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- C. The output power section shall change fixed DC voltage to adjustable frequency AC voltage. This section shall utilize intelligent power modules (IPMs), as required by the current rating of the motor.

## 2.3 CONSTRUCTION

- A. The AC Drive power converter shall be enclosed in a Type 1, or Type 12K enclosure with top and bottom conduit knockouts with a circuit breaker disconnect, industrial rated operator controls, user terminal strip connections and bypass controls (if required).
- B. The enclosure shall provide dedicated user terminals for power and control device connection.
- C. Provisions shall be included for locking the disconnect in the OFF position with a padlock.
- D. All enclosure and heatsink fans shall be front accessible and not require the removal of the AC drive power converter.

## 2.4 MOTOR DATA

- A. The AC Drive shall be sized to operate the following AC motor:
  - 1. Motor horsepower.
  - 2. Motor full load amperes.
  - 3. Motor rpm will be 1800 at 60 Hz.
  - 4. Motor voltage will be 208, 230, or 460 as indicated on the drawings
  - 5. Motor service factor will be 1.15.
  - 6. NEMA MG1 Part 31.

## 2.5 APPLICATION DATA

- A. The AC Drive shall be sized to operate a Variable Torque load.
- B. The speed range shall be from a minimum speed of 1.0 Hz to a maximum speed of 60 Hz.

## 2.6 ENVIRONMENTAL RATINGS

- A. The AC Drive shall meet IEC 664-1 and NEMA ICS 1 Standards.
- B. The AC Drive shall be designed to operate in an ambient temperature from 0 <C to 40 <C (32 <F to 104 <F).
- C. The storage temperature range shall be -25 <C to 65 <C (-13 <F to 149 <F).
- D. The maximum relative humidity shall be 95% at 40 <C (104 <F), non-condensing.
- E. The AC Drive shall be rated to operate at altitudes less than or equal to 3,300 ft (1000 m). For altitudes above 3,300 ft (1,000 m), derate the AC Drive by 1% for every 330 ft (100 m).
- F. The AC Drive shall meet the IEC 721-3-3-3M3 operational vibration specification.

2.7 RATINGS

- A. The AC Drive shall be designed to operate from an input voltage of 460 VAC (") 10%, 230 VAC (") 10%, 208 VAC (") 10%.
- B. The AC Drive shall operate from an input frequency range of 60 (") 5%.
- C. The displacement power factor shall not be less than 0.98 lagging under any speed or load condition.
- D. The efficiency of the AC Drive at 100% speed and load shall not be less than 97%.
- E. The variable torque rated AC Drive over current capacity shall be not less than 110% for 1 minute.
- F. The output carrier frequency of the AC Drive shall be programmable at 0.5, 1, 2, 4, or 8 kHz. In addition, the output carrier frequency shall be randomly modulated about the selected frequency.

2.8 PROTECTION

- A. Upon power-up, the AC Drive shall automatically test for valid operation of memory, loss of analog reference input, loss of communication, DC-to-DC power supply, control power and pre-charge circuit.
- B. Shaft grounding rings shall be incorporated into motors 10HP and higher to prevent electrically induced bearing damage when VFDs are utilized on larger pump and fan motors. Coordinate work with drive and equipment manufacturers.
- C. The enclosure shall provide a fully-coordinated 22 kAIC rating marked on the enclosure nameplate. Short circuit coordination to UL508C Power Conversion Equipment and NEMA ICS 7.1.
- D. The AC Drive shall be protected against short circuits, between output phases and to ground.
- E. The AC Drive shall have a minimum AC undervoltage power loss ride-through of 200 milliseconds.
- F. The AC drive shall have a programmable ride through function, which will allow the logic to maintain control for a minimum of one second (60 cycles) without faulting.
- G. For a fault condition other than a ground fault, short circuit or internal fault, an auto restart function will provide up to 6 programmable restart attempts. The time delay before restart attempts will be 30 seconds.
- H. Upon loss of the analog process follower reference signal, the AC Drive shall be programmable to display a fault.
- I. The AC Drive shall have a solid-state overload that is listed as a UL 508 C overload protective device and meets IEC 947.
- J. The output frequency shall be software enabled to fold back when the motor is overloaded.
- K. There shall be one skip frequency range that can be programmed to a bandwidth of  $\pm 2.5$  Hz.
- L. Provide phase loss protection at the motor with the application of an appropriate relay so that overloads trip during the loss of a single phase to the motor.

## 2.9 ADJUSTMENTS AND CONFIGURATIONS

- A. The AC Drive will be factory programmed to operate all specified optional devices.
- B. The acceleration and deceleration ramp times shall be adjustable from 0.05 to 999.9 seconds.
- C. The memory shall retain and record run status and fault type of the past 8 faults.
- D. The software shall have an Energy Economy function that, when selected, will reduce the voltage to the motor when selected for variable torque loads. A constant volts/Hz ratio will be maintained during acceleration. The output voltage will then automatically adjust to meet the torque requirement of the load.

## 2.10 KEYPAD DISPLAY INTERFACE

- A. The keypad display interface shall offer the modification of AC Drive adjustments via a touch keypad. All electrical values, configuration parameters, I/O assignments, application and activity function access, faults, local control, and adjustment storage, and diagnostics shall be in plain English. There will be a standard selection of 4 additional languages built-in to the operating software as standard.
- B. The display will be a high resolution, LCD back-lit screen.
- C. The AC Drive model number, torque type, software revision number, horsepower, output current, motor frequency, and motor voltage shall be listed on the drive identification portion of the LCD display.
- D. The keypad display shall consist of programmable function keys that allow both operating commands and programming options to be preset by the operator. A hardware selector switch shall allow the terminal keypad to be locked out from unauthorized personnel.

## 2.11 OPERATOR CONTROLS

- A. The control power for the digital inputs and outputs shall be 24 VDC.
- B. The internal power supply shall incorporate automatic current fold-back that protects the internal power supply if incorrectly connected or shorted. The transistor logic outputs will be current limited and will not be damaged if shorted.
- C. Pull-apart terminal strips shall be used on all logic and analog signal connections in the power converter.
- D. Two voltage-free relay output contacts will be provided. One of the contacts will indicate AC Drive fault status. The other contact shall indicate a drive run status.
- E. The combination enclosure shall have the following dedicated operator controls:
  - 1. Hand-Off-Auto switch and Start-Stop push button
  - 2. Manual Speed Potentiometer
  - 3. AFC-Off-Bypass switch
  - 4. Test-Normal Selector switch
  - 5. Power On (red) LED indicator
  - 6. Drive Run (green) LED indicator
  - 7. Drive Fault (yellow) LED indicator
  - 8. Auto Mode (yellow) or Bypass Run (yellow) LED indicator.

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- F. The combination enclosure shall include a 120 VAC smoke purge relay option (if required). A user-supplied 120 VAC signal shall be sequenced in accordance with local fire protection codes and will switch the AC drive to 60 Hz operation for maximum fan motor speed. If drive bypass is supplied, the smoke purge relay will isolate the AC Drive and run the fan motor at full speed on bypass.
- G. The combination enclosure shall include terminal point connection for fire/freeze stat interlock, to prevent drive or bypass operation.

2.12 DRIVE ISOLATION AND BYPASS CONTACTORS.

- A. The AC Drive shall include mechanically and electrically interlocked isolation and bypass contactors complete with Class 20 thermal overload relay, circuit breaker disconnect, control circuit transformer, AFC/OFF/BYPASS switch and TEST/NORMAL selector switch.
- B. The operator shall have full control of the bypass starter by operation of the AFC/OFF/BYPASS selector switch.
- C. In the AUTOMATIC mode of operation, the bypass contactors shall be sequenced by the 110-volt rated auto start contact provided by the user.
- D. The isolation contactor for the bypass shall be sequenced to provide motor isolation during a drive ready state of operation.
- E. A TEST/NORMAL selector switch shall provide test operation of the power converter while operating the motor in bypass.

2.13 HARMONIC MITIGATION

- A. Provide 5 percent line reactors. The line reactors shall be mounted inside the drive enclosure.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive Adjustable frequency drives 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 drive installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Select features of each drive to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, drive, and load.
- B. Select rating of controllers to suit motor controlled.

3.3 INSTALLATION

- A. Installation shall be in compliance with manufacturer's instructions, drawings and recommendations.
- B. The AC Drive manufacturer shall provide a factory certified technical representative to inspect the contractor's installation, test, and start-up the AC Drive(s) furnished under this specification. The start-up service shall be quoted as a separate line item.

3.4 IDENTIFICATION

- A. Identify Adjustable frequency drives, components, and control wiring according to standard practice.

3.5 CONNECTIONS

- A. Conduit installation requirements are specified in other Division 16 Sections.
- B. Ground equipment.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.6 STARTUP SERVICE

- A. Start-up service shall be provided by the equipment manufacturer's authorized representative and shall include complete testing of all controls and unit operation. The agency responsible for start-up shall provide copies of this data are to the owner.
- B. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
- C. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

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

3.8 CLEANING

- A. Clean Adjustable frequency drives internally, on completion of installation, according to manufacturer's written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.9 TRAINING

- A. An on-site training course of 1/2 training days shall be provided by a representative of the AC Drive manufacturer to plant and/or maintenance personnel as an option.



3.10 DOCUMENTATION

- A. The AC Drive manufacturer shall supply a comprehensive 8-1/2" x 11" bound instruction/installation manual that includes wiring diagrams, layout diagrams, and outline dimensions. This manual must be 3-hole punched for insertion in a shop manual supplied by the installing contractor.

END OF SECTION 23 89 00