

## SECTION 230975 – ADJUSTABLE FREQUENCY DRIVE UNITS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

#### 1.2 MECHANICAL GENERAL PROVISIONS

- B. The Contractor shall conform to the General Conditions.

#### 1.3 WORK INCLUDED

- A. Adjustable frequency drive units

#### 1.4 QUALITY ASSURANCE

- A. All components to be UL listed or labeled.
- B. All wiring to conform to the NEC.
- C. All enclosures to be NEMA rated.
- D. All drives exposed to weather or wet situations shall be enclosed in a NEMA 3R enclosure.
- E. All units shall conform to Part 15 of the FCC regulations on RFI/EMI emissions.
- F. The power converter section of every VFD shall be tested with an actual AC induction motor while loaded and temperature cycled within an environment chamber at 40° C (104° F).
- G. After installation the manufacturer's representative of the equipment provided in this section shall certify in writing to the Owner's representative that the equipment has been assembled and installed within the guidelines of the manufacturer's written installation instructions and that its performance meets or exceeds the operating characteristics specified and/or scheduled and that its emissions are within the limits set by the aforementioned regulations.
- H. A Field Service Engineer is to be provided for start up assistance for the drive and its related motor. Start up assistance shall consist of verifying factory performance standards for the drive and aiding in establishing reference speed points for control of the motor.
- I. Provide warranty period for VFDs and any bypass for 36 months minimum, inclusive of parts, travel, labor and shipping required for repair from date of shipment.

## 1.5 SUBMITTALS

- A. Submit complete performance and dimensional data along with construction details and wiring diagrams.
- B. Submit manufacturer's installation instructions.

## PART 2 - PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

- A. Adjustable Frequency Drive Units:
  - 1. ABB
  - 2. Square D
  - 3. Eaton
  - 4. Yaskawa

### 2.2 EQUIPMENT REQUIREMENTS

- A. The inverters are to be selected for operation with the motors provided for this project. The drive system shall provide an input power factor of 95% throughout the entire speed range. The inverter shall not contribute 5th or 7th harmonic current to the power distribution system or contain the appropriate filter network to limit those harmonics to not more than 5% of the theoretical value.
- B. The input power section of the power converter shall utilize a full wave bridge frequency AC line power to fixed DC voltage. This power section shall be insensitive to phase rotation of the AC line. The output power section of the power converter shall change fixed DC voltage to adjustable frequency AC voltage, utilizing insulated gate bipolar transistors (IGBTs).
- C. The inverter shall be a 12-pulse width modulating type for maximum reliability and provide inherent short circuit protection. The inverter shall be capable of withstanding an output phase to phase, phase to ground short circuit and inverter semi-conductor short circuit, without causing a failure to the inverter. The drive system shall provide a near unity power factor. It is to provide operation of the fan motors as scheduled. Units shall be mounted in a NEMA 12 or better enclosure, and shall be rated for installation in a plenum environment. The following equipment and features are to be incorporated:
  - 1. Fully range minimum and maximum speed adjustment with ability to automatically select speeds.
  - 2. Adjustable linear acceleration and deceleration, each separately adjustable.

3. Field adjustable or automatic current limit.
  4. Inherent short circuit protection.
  5. All units shall operate from 4-20 ma signal in automatic mode.
  6. Under voltage and over voltage protection.
  7. Over temperature protection.
  8. Be rated to provide 100% of rated current, minimum 110% break away current.
  9. Inverter is to be rated for an input line voltage variation of +10% and -5%.
  10. Inverter is to include a door interlocked disconnect switch or circuit breaker. If integral disconnect is not supplied, the manufacturer shall furnish a separate disconnect with inverter. Manufacturer shall also furnish all step-up/step-down transformers required if inverter and motor are not ground voltage. Current limiting fuses shall be wired to the power converter input, and shall be installed in the combination enclosure.
  11. The following are to be included in the inverter cabinet:
    - a. Filtered ventilation louvers or heat sinks.
    - b. Door mounted analog or digital speed indicator calibrated 0-100%.
    - c. Power on light.
    - d. Fault light.
    - e. Fault reset button.
    - f. Manual speed potentiometer for operation in the manual mode.
    - g. Manual-off-automatic switch.
    - h. Manually switched bypass circuit to bypass power feed around the inverter.
    - i. Temperature controlled cooling fan.
- D. Unit to include automatic restart circuitry in the event of a power outage, with no more than a 60 second delay after power is reapplied. Unit shall try at least three re-starts before shut-down and alarm.
- E. Environmental Ratings
1. The VFD shall be designed to operate in a pollution Degree-2 environment. The VFD shall meet IEC 664-1 and NEMA ICS 1 Standards.
  2. The storage temperature range shall be -25° C to 70° C (-13° F to 158° F).
  3. The maximum relative humidity shall be 95% at 40° C (104° F), non-condensing.
  4. The VFD shall be rated to operate at altitudes less than or equal to 3,300 ft (1000m). For altitudes above 3,300 ft (1,000 m), de-rate the VFD by 1.2% for every 330 ft (100m).
  5. The VFD shall meet the IEC 68-2 operational vibration specification.
- F. Performance Ratings
1. The VFD shall be designed to operate ( $\pm$ ) 10% of rated voltage
  2. The VFD shall operate from an input frequency range of 47.5 to 63-Hz.
  3. The displacement power factor shall not be less than 0.95 lagging under any speed or load condition.
  4. The efficiency of the VFD at 100% speed and load shall not be less than 96%.
  5. The variable torque rated VFD over current capacity shall be not less than 110 % for 1-minute.

6. The output carrier frequency of the VFD shall be programmable at 2, 4 or 10-kHz. In addition, the output carrier frequency shall be randomly modulated about the selected frequency. VFDs with an operable carrier frequency above 10-kHz shall not be allowed.
7. Provide with temperature controlled cooling fans.

G. Protection

1. Upon power-up, the VFD 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.
2. The VFD shall be UL 508A or 508C listed for the available fault as determined available by the designer, but no less than 22,000-A rms fault current for 460 V drives. For 208-VAC distribution systems, the UL508C listing shall be for 8,800-A rms of minimum available fault current. The Power Converter shall meet the short circuit specifications defined by NEMA ICS 7.1.09, and have the value listed on the VFD nameplate.
3. The VFD shall be protected against short circuits between output phases and to ground.
4. The VFD shall have a minimum AC under voltage power loss ride-through of 200 milliseconds (12 cycles).
5. The VFD 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.
6. For a fault condition other than a ground fault, short circuit or internal fault, an auto restart function will provide up to 5 programmable restart attempts. The programmable time delay before restart attempts will range from 1 second to 600 seconds.
7. Upon loss of the analog input speed reference signal, the VFD shall fault and / or operate at a user-defined speed set between programmed low- and high-speed settings.
8. The VFD shall include solid-state protection that is UL listed and that meets UL 508 C as a Class 10 overload protective device and meets IEC 947. The minimum adjustment range shall be from .45 to 1.05% of the current output of the VFD.
9. The output frequency shall be software -controlled to reduce frequency (fold back) when the motor is overloaded.
10. There shall be three skip frequency ranges that can each be programmed to a bandwidth of 2 or 5 Hz. The skip frequencies shall be programmed independently, back to back, or overlapping.
11. For motors 5 hp and larger provide Shaft Grounding Rings, to protect the motors against VFD induced damage such as motor bearing failure.
12. The VFD shall include 'output phase imbalance' fault indication.
13. The VFD shall include DC link reactors to minimize power line harmonics and to provide near unity power factor.

H. Adjustments & Configurations

1. The VFD will be factory programmed to operate all specified optional devices.
2. The acceleration and deceleration ramp times shall be adjustable from 1 to 999 seconds.
3. The memory shall retain and record run status and fault type of the past 8 faults.
4. The software shall have a no load function that, when selected, will reduce the voltage to the motor 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.

5. Provide a programmable Automatic Energy Optimization (AEO) selection feature to optimize motor magnetization voltage and minimize energy consumption in variable torque applications. This feature should dynamically and continuously adjust output voltage in response to load, independent of speed.
6. Provide an Automatic Motor Adaptation (AMA) function measuring motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to spin the motor shaft or decouple the motor from the load to accomplish this optimization. Additionally, the parameters for motor resistance and motor reactance shall be user-programmable.

I. Keypad Display Interface

1. The keypad display interface shall enable adjustments to the VFD via a touch keypad. All electrical values, configuration parameters, I/O assignments, application and activity function access, faults, local control, adjustment storage, self-test and diagnostics shall be in plain English.
2. The display will be a high resolution, LCD back-lit screen capable of displaying graphics such as bar graphs as well as six lines of 21 alphanumeric characters.
3. The VFD 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.
4. The keypad display shall be configured to display one or two bar graphs with numeric data that are programmable by the operator. As a minimum the programmable outputs shall consist of speed reference, output frequency, output current, motor torque, output power, output voltage, line voltage, DC voltage, motor thermal state, drive thermal state, elapsed time, motor speed, machine speed reference and machine speed.
5. 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.
6. A RUN key and a STOP key will command a normal starting and stopping as programmed when the VFD is in keypad control mode. The STOP key must be active in all control modes.
7. The VFD shall have three LEDs mounted on the front panel to indicate functional status. A green LED will verify that the VFD power supply is on. A red LED indicator will indicate an VFD fault. A yellow LED indicator will designate a pending fault condition.

J. Operator Control Interface

1. The control power for the digital inputs and outputs shall be 24 VDC.
2. 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.
3. Pull-apart terminal strips shall be used on all logic and analog signal connections in the power converter.
4. Input requirements; four isolated digital logic inputs and two isolated analog inputs (one 0 - 10VDC speed potentiometer and one 4-20mA speed reference).
5. Output requirements; two digital logic outputs, two voltage-free relay output contacts (fault status and a programmable drive run), and two isolated 4 – 20 mA analog outputs

- that can be selected and assigned in the software (and be proportional to the following motor characteristics: frequency, current, power torque, voltage and thermal state ).
6. The combination enclosure shall have the following dedicated operator controls:
    - a. Hand-Off-Auto switch
    - b. Manual Speed Potentiometer
    - c. VFD-Off-Bypass switch
  7. The hands-off-auto function which provides seamless transfer from EMCS control to hand control and back, without interruption of motor speed on transfer...The optional 120 VAC smoke purge relay shall be installed in the combination enclosure, and shall enable the VFD to be sequenced in accordance with local fire protection codes. A user-supplied 120 VAC signal will switch the VFD to 60 Hz operation for maximum fan motor speed. If drive bypass is supplied, the smoke purge relay will isolate the VFD and run the fan motor full speed on bypass
  8. The combination enclosure shall also include terminal point connection for fire /freeze stat interlock, to prevent drive or bypass operation.
  9. VFDS shall be furnished with a BacNet compatible interface
  10. VFDs installed will provide the following data points to the BAS - All inputs used in PID or Speed Control, Drive Status, Speed (Rpm and Hz), Amperage Draw. All new VFDs will have BACNet connectivity.
  11. VFS with bypass mode shall a drive disconnect, a two contactor bypass for full speed operation, and isolation barriers between the VFD and bypass. Specify VFD's with bypass when installed on fan motors.
  12. The combination enclosure shall include a pair of IEC rated bypass contactors (complete with thermal overload relays) to isolate the VFD output during the bypass mode and to coincidentally provide line power directly to the motor. It shall also include fuses on the line side of the VFD to enable isolation, a circuit breaker disconnect, control circuit transformer, motor flux decay timer and VFD/OFF/BYPASS switch. The operator shall have full control of the bypass contactors by operation of the combination enclosure mounted selector switch.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install in accordance with manufacturer's written installation instructions.
- B. Install line filters where required by manufacturer's recommendations.
- C. Cabling from the drive to the motor shall consist of three (3) stranded copper TC circuit conductors with XLPE insulation. Shielding shall be provided consisting of two spiral copper tape shields (100% coverage). Provide with three (3) full size bare copper grounds.
- D. The contractor shall assume the responsibility for coordinating the purchased equipment with the motor served and with the automatic temperature control system, paying specific attention to the signal sent and received the ground source and the required speed range.

- E. Start-up shall be by a factory trained field service engineer representing the manufacturer of the equipment purchased. Start-up shall be done in the presence of the controls contractor and the engineer.
- F. Training: A one-day on-site training course shall be provided by a representative of the VFD manufacturer to plant and/or maintenance personnel.
- G. Documentation: The VFD manufacturer shall supply a comprehensive 8-1/2" x 11" spiral bound instruction-installation manual that includes wiring diagrams and layout.

END OF SECTION 230975

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