

SECTION 15065  
VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 PROVISIONS INCLUDED

- A. The general provisions of the Contract, including General and Supplementary General Conditions, and Division 1 General Requirements, apply to work specified in this Section.
- B. Requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work specified in this Section.

1.02 SUMMARY

- A. Furnish and install variable frequency drives (VFDs) as part of the air handler units, fume exhaust energy recovery unit, pumps, fans and mechanical equipment as indicated within the mechanical equipment specification sections and drawing schedules. Variable frequency drives to be compatible with the equipment to be controlled.
- B. Installation by electrical contractor, in accordance with all applicable Division 16 specification sections.
- C. Related Work Specified in Other Sections:
  - 1. Power Wiring: Division 16, Electrical

1.03 SUBMITTALS

- A. Product Data: Submit manufacturer's catalogue cuts for each type of VFD. Submit manufacturer's instructions for handling, installation, application conditions, preparation, operation, maintenance, and protection of the VFD.
- B. Shop Drawings: Prepare and submit a complete set of dimensioned drawings and electrical wiring diagrams for each VFD provided.
- C. Harmonic Analysis: Prepare and submit a harmonic analysis specific to this installation and showing compliance to IEEE-519-1992. The analysis shall be done based on the KVA capacity and impedance of the service transformer, and resistance and impedance of the feeder leading to each VFD. The results shall list the voltage and current amplitudes of all harmonics up to the 31st level and the percentage of total harmonic distortion.
- D. All VFD submittals are to accompany the mechanical equipment submittal it is being provided with.

1.04 OPERATION AND MAINTENANCE MANUALS

- A. The manuals shall include a table of contents, specifications, drawings, and description of equipment; installation instructions; operating instructions; Maintenance instructions; parts

lists; and test data and performance curves. The table of contents shall be marked with the Owner's name, project name, equipment name, and the Owner's purchase order number.

- B. Where applicable, the information contained in the manual shall include a list of recommended spare parts and a schedule of required lubricants, as recommended by the Manufacturer. The data shall also include all nameplate information and shop order numbers for each item of equipment and component part thereof.
- C. Six copies of complete and final operation and maintenance manuals, including one set, suitable for reproduction.

#### 1.05 QUALITY ASSURANCE

- A. National Electrical Code Compliance: Provide components complying with NFPA 70 National Electrical Code.
- B. Manufacturer Qualifications: Firm with at least 5 years experience in manufacturing VFDs of types and sizes required for this Project. Firm must have a record of successful in-service performance.
- C. VFD equipment UL listed, and designed to meet requirements of IEC 801-2 and IEC 801-4 standards.
- D. Fully assembled VFD shall be factory tested with nominally loaded induction motors.

#### 1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect VFD equipment from dirt and moisture by securely wrapping in heavy plastic.
- B. Store VFD to protect from condensation on or in VFD cabinet.

#### 1.07 WARRANTY

- A. Provide 2 year parts and labor warranty that VFD equipment be free from defects in material and workmanship. Warranty to commence on date of acceptance by Owner.
- B. This warranty shall be in addition to and not in lieu of other warranties required by Contract Documents and other rights and remedies available to Owner under law.

### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

- A. Subject to compliance with requirements, provide variable frequency drives by one of the following:
  1. ASEA Brown Boveri
  2. Magnetek
  3. Toshiba

## 2.02 GENERAL

- A. General: VFD units vary the speed of three-phase induction motors by converting the fixed utility input voltage 480-volt 60-hertz to a variable voltage and frequency output.
- B. Power Structure: Solid state with a three-phase full wave diode rectifier, fixed voltage DC bus with bus choke and filter capacitors, and pulse width modulated (PWM) transistorized inverter to convert DC bus power to sine-coded PWM voltage source power for motor speed control. Insulated Gated Bipolar Transistors (IGBT) to be employed as output switching device.
- C. Enclosure: Wall mounted NEMA 1 completely assembled enclosure with a Hand-Off-Automatic (HOA) selector switch. All components in VFD totally accessible through door opening.
- D. Provide a circuit breaker or a load break switch on the line side of the variable frequency drive, with a padlockable door. Isolate breaker or switch from VFD compartment. Interlock door with breaker or switch to prevent door from being opened while breaker is closed. Provide a mechanism for defeating the interlock for service personnel only. Label VFD door as "INTERLOCKED DOOR."
- E. Standard operating conditions shall be:
  - 1. Incoming three phase power, programmable to 480 volt, plus or minus 10%.
  - 2. Humidity 0 to 95% (noncondensing and noncorrosive).
  - 3. Altitude 0 to 3,300 feet above sea level.
  - 4. Ambient temperature 0 to 40 degrees C.
- F. Attach a nameplate to VFD identifying size and type of VFD, and motor for which VFD is rated.
- G. Input circuit breaker short circuit rating: Minimum 35,000 Amp symmetrical RMS.

## 2.03 VFD PERFORMANCE

- A. Efficiency: 97 percent or greater at the motor nominal speed and load, and not less than 90 percent at 50 percent speed.
- B. Displacement Power Factor: 0.95 or greater, regardless of speed and load.
- C. Torque: Provide sufficient torque to start a motor which can be started on the AC line with a full voltage starter; provide ability to start into a rotating load and accelerate or decelerate without safety tripping or component damage.
- D. Restarts: Automatic restart, with number of restarts adjustable to 5. VFD to include adjustable trial time up to 180 seconds to define time period for pre-programmed number of re-start attempts. After counting to number of selected restarts, VFD shall require a reset with a door mounted reset push-button. VFD capable of automatically restarting after power is lost; autorestart not allowed for fault clearing.
- E. VFD to include the following features:

1. Orderly shutdown upon any drive fault, without component damage.
2. VFD output current up to 125 percent of motor full load amperes, for one minute.
3. Separately adjustable acceleration and deceleration time from 0.1 to 300 seconds.
4. Totally customized volts per hertz pattern. VFD output power to vary frequency to motor from 3 hertz to 60 hertz with output voltage variation for optimum volts per hertz ratio.
5. Optimized inverter carrier frequency to reduce induced magnetic audible motor noise such that, under VFD power, motor noise will not increase by more than 2db at 3 feet above the across-the-line power, or an output reactor shall be included to reduce this noise.
6. Critical frequency rejection capability with a minimum of three programmable critical frequency lockout ranges to prevent VFD from continuously operating at an unstable speed.
7. Separately adjustable minimum and maximum output frequency.
8. Protection against a stalled motor. Include adjustable stall current limit and stall frequency/time ratio.
9. 5 cycle regulator control power dip ride-through.
10. VFD defaults to a fail safe mode at an adjustable setting preset by Owner, upon loss of automatic speed regulation signal.

F. IEEE-519 Compliance

1. Provide calculations specific to this installation showing Total Harmonic Distortion for VFD's, reflected into the electrical distribution system, is limited to the level defined by IEEE-519-1992 for general systems. Include harmonic analysis with VFD submittal for approval by Architect.
2. Provide factory trained manufacturer's representative to conduct on site harmonic measurements before and after start up of VFD's. Provide a written report on results of measurements showing harmonic contribution of VFD's, to Architect no later than one month after start up.
3. Should site measurements show IEEE-519 levels have been exceeded, VFD manufacturer will provide proper filtering to attain IEEE-519 levels, at no additional cost to Owner.
4. As a minimum, provide three phase, A.C. input line reactors with all VFD's. Line reactors are to provide attenuation of line side voltage transients, preventing overload trips or other unnecessary VFD shutdown, and provide a reduction in harmonic distortion.
5. Line reactors must meet the following requirements:

- a. Minimum of 2 ½% line impedance
- b. 150% continuous current rating for one minute.
- c. Saturation rating no less than 2.5 times continuous current rating.
- d. U.L. recognized.

#### 2.04 MANUAL BYPASS

- A. Provide bypass control to run motor at full speed with line power when VFD is not operational. Configure cabinet to permit VFD removal with bypass control left in place. Complete VFD and bypass system contained in a single NEMA 1 enclosure.
- B. Bypass to include VFD output contractor electrically and mechanically interlocked with a bypass contactor, motor overload relay, control logic, status lights, and VFD-OFF-BYPASS selector switch.

#### 2.05 VFD CONTROL, DIAGNOSTIC AND PROTECTION.

- A. Provide the following digital diagnostic and protection circuits:
  1. Instantaneous overcurrent protection
  2. DC bus overdrive and undervoltage
  3. Ground fault protection
  4. Input single phase loss
  5. Motor overload to protect motor based on load curve and speed
  6. Overtemperature
  7. VFD logic fault
- B. Display: Provide front mounted digital control key pad and plain English display to provide following operating information and control functions:
  1. Output frequency meter.
  2. Motor speed in RPM.
  3. Output voltmeter.
  4. Output ammeter.
  5. Operating kilowatts.
  6. Heatsink temperature.
  7. Run/stop selection keys.
  8. Auto/manual speed control selection.
  9. Manual speed adjustment.
  10. Reset push button.
  11. Elapsed time meter.
  12. Kilowatt hour meter.
- C. Clock: Provide a real time clock with dated recording of all faults. Retain a minimum of four last faults in VFD memory with the date and time stamp.
- D. Provide VFD capable of programming various control functions without stopping drive while in Run Mode.
- E. Interface functions:
  1. Start/Stop command through HOA switch when in "Auto" mode.

2. Speed reference inputs capable of receiving an analog signal of 4 to 20ma DC current or 0 to 10 volt DC, isolated or non-isolated from ground and able to be inverted, so that minimum reference corresponds to maximum speed, and maximum reference corresponds to minimum speed.
  3. Run/stop command from external normally-open contact or switch (two-wire dry contact closure, three-wire or 120 volt AC input signal)
  4. RS232/485 communication port for connection to Owner's DDC control system.
  5. Analog output signal from 0 to 10 volt DC, or 4 to 20ma DC, proportional to either output frequency or output current.
  6. Normally open output contacts for VFD run, fault, and auto-restart failure conditions. Contacts rated for at least 1 ampere at 240 volt AC or 30 volt DC.
  7. Capable of communicating on the following buses with no additional hardware and software:
    - a. Johnson Controls N2 Bus.
    - b. Landis and Staefa P1 Bus.
    - c. Modbus
    - d. Honeywell Bus
    - e. Delta Controls
- F. VFD to include three current limit circuits to provide trip free operation:
1. Slow Current Regulation limit circuit adjustable to 125% (minimum) of VFD's variable torque current rating. Adjustment made via keypad and displayed in actual amps.
  2. Rapid Current Regulation limit adjustable to 170% (minimum) of VFD's variable torque current rating.
  3. Current Switch—off limit shall be fixed at 255% (minimum, instantaneous) of VFD's variable torque current rating.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install VFD in accordance with the National Electrical Code, approved shop drawings, and manufacturer's recommendations.

### 3.02 TESTING

- A. Test, check out, and start-up VFD equipment under direction of manufacturer's service engineer. Under no circumstances are any portions of the drive system to be energized without authorization from manufacturer's representative.
- B. VFD manufacturer to provide start-up service for all VFD's furnished under this contract. Include inspection, final adjustments, operational checks, functional checks of spare parts, and a final report for record purpose.

- C. Submit one copy of all tests and checks performed in the field, complete with meter readings and recordings where applicable, to Owner.
- D. Comply with USM IDAT per section 01810.

3.03 DEMONSTRATION

- A. Manufacturer to provide a one day training course for Owner's personnel at the job site. This course shall be taught by personnel experienced in operating and maintaining the equipment and in training other operators.

END OF SECTION 15065