PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Definitions: The Variable Speed AC Motor Drive (hereafter referred to as "VFD") shall be designed to convert 480 Volt, 60 Hertz input power to adjustable frequency output power. The output frequency and voltage of the drive shall be adjustable such that a constant volts/Hz ratio is maintained throughout the operating range.

B. Interface: The contractor, (hereafter referred to as "supplier"), shall furnish VFD according to the schedule in the mechanical drawings and in compliance with all requirements described in this specification. The supplier shall also review the mechanical, electrical, and control plans and specifications for coordination. Substitutions or options affecting price shall be offered as alternates unless approved otherwise by the University's Project Engineer.

C. Performance: Each VFD shall be designed to operate on any standard NEMA Design B motor at the given horsepower with allowance for a 1.15 motor service factor.

1.2 REFERENCES

A. Organizations:

1. American National Standards Institute (ANSI)
2. National Electrical Manufacturer's Association (NEMA)
3. Underwriter's Laboratories (UL)
4. Canadian Standards Association (CSA)
5. Electronics Testing Laboratories (ETL)
B. Codes and Standards:

IEEE 519 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

NEMA ICS 7.1 Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems

FCC Rules and Regulations, Part 15, Subpart J, Class A RFI Levels

C. General:

1. Equipment shall be designed and manufactured in accordance with all applicable current ANSI and NEMA standards in addition to those referenced above in this section. Equipment shall be designed for installation per NEC and shall have approval by one or more of the following: UL, CSA, ETL.

1.3 SUBMITTALS

A. The VFD supplier shall submit the following:

1. Schematic Diagram and Parts List (including spare parts).
2. Any information necessary to clarify variations to this standard, or coordination necessary with other trades.
3. Outline drawings showing overall dimensions, mounting provisions weights, clearances, points of connection for power, load and control.
4. One copy of the VFD operation manuals.

1.4 CLOSEOUT SUBMITTALS

A. QUALIFICATIONS

1. Acceptable Manufacturers: Allen-Bradley or approved equal.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Shipment Protection:

1. The method of preparation for shipment shall protect the VFDs including all parts, auxiliary devices and accessories against corrosion, dampness breakage, or vibration injury that might be encountered in transportation and handling. The manner of packaging shall be such as to prevent
tampering or pilfering and shall be acceptable to transportation companies.

2. The VFD shall be protected against damage at all times. The supplier shall follow the manufacturer's instructions for on-site storage and handling.

B. Unit Pre-assembly: The units shall be delivered in the largest subassemblies practical for transportation.

1.6 WARRANTY

A. General: The VFD manufacturer shall provide a one (1) year (or greater) warranty on all VFD parts and labor

PART 2 -PRODUCTS

2.1 EQUIPMENT

A. VFD type: The VFD shall be a "voltage source" type. Either a step inverter or pulse width modulation system is acceptable.

B. Design Parameters

1. The VFD shall be designed to operate in the following temperature and humidity ranges without interruption or impairment of continuous service:
   a. Temperature: Zero to forty (0-40°C) degrees C
   b. Humidity: Zero to ninety-five (0-95%) percent, non-condensing.

2. The VFD shall be designed to operate under plus ten (+10%) percent, minus five (-5%) percent line voltage variations and plus or minus (+/-) two (2) Hertz incoming line frequency variation.

3. The VFD shall be designed to operate properly on either normal utility or backup generator power.

C. Features:

1. NEMA 1 or 12 unit enclosure with hinged front access door, containing static power conversion equipment and necessary controls, mounted, wired and tested. All components shall be accessible from the cabinet door for service.

2. Externally operated disconnect switch, interlocked with enclosure door, with short circuit interrupting rating of 200,000 amperes (A). The disconnect shall be configured to isolate the drive for service in accordance with NFPA 70E.
3. Internal 115V AC control power circuit with transformer and protective fuses.

4. All exposed terminals greater than 50V to be guarded per NFPA-70E.

5. One normally open (NO) and one normally closed (NC) auxiliary contacts from run relay, wired to terminal for customer use. Lugs shall be provided for incoming cable.

6. Door-mounted AC ammeter, speed indicator, and speed potentiometer or digital control panel.

7. The VFD shall be capable of operating from a four to twenty (4-20) milliampere (mA) DC externally powered signal (provided by the controls contractor). The VFD shall contain terminals to receive a two-wire external signal, and control modules to process this signal and linearly modulate frequency over operating range.

8. HAND/OFF/AUTO feature for local service.

9. Drive fault contact for remote indication.

10. Automatic restart following a power outage.

11. Hardwire safety stop for fire alarm interface not subject to any bypass or override operation.

12. Integral motor overload relay.

13. Manual bypass features shall be provided to fully isolate the VFD from both line and load connections. The bypass equipment shall be located in a separate enclosure and shall allow constant-speed motor operation across the line during maintenance shutdown of VFD unit. The bypass shall include starter overload protection and required safety interlocks. (Note: Automatic bypass may be supplied as an alternate subject to University Project Engineer approval.)

14. The following control functions shall be provided:
    a. Torque or current limit regulator. This regulator shall act automatically to prevent a trip from momentary overload conditions allowing the inverter to continue operation.
    b. Linear timed acceleration and deceleration, separately adjustable, with regeneration protection during deceleration.
    c. Speed regulator, with remote adjust by four to twenty (4-20) mA signal. Speed control shall have steady state accuracy of plus or minus one (+1%) percent of full speed.
    d. Current and voltage feedback with isolation.
    e. Local start, stop, and speed controls.
    f. Safe stop on protection signal.
g. Separately adjustable min/max frequency limits and/or step-over capability.

15. Equipment protection is defined as normal shutdown with no component damage. The VFD shall be designed for equipment protection from all the following:
   a. Normal transients and surges in the incoming power line.
   b. Any grounding or disconnecting of output power.
   c. Any interruption or runaway of the incoming speed reference signal.
   d. Phase-to-phase or phase-to-ground faults.
   e. Removal of load without time delay considerations.
   f. Single phasing, power outages.

16. The following internal protection functions shall be provided, where applicable:
   a. Open phase or missing gate.
   b. Commutation failure.
   c. Loss of cooling air and/or reactor over temperature.
   d. Loss of logic control power.
   e. Loss of gate power supply.

17. The VFD shall incorporate the following additional protective features:
   a. Capability to start into a spinning motor without component damage.
   b. Ride through an input power dip of one (1) cycle or less.
   c. Orderly shutdown when the incoming voltage low limit is surpassed.
   d. Instantaneous overcurrent trip, which shall continuously monitor peak currents and shut down the VFD when the high limit setting is surpassed.

18. The following diagnostic capabilities shall be provided:
   a. Continuous on-line self diagnostics including predictive fan failure.
   b. Ability to monitor major system components with status lights for replaceable elements. Individual indicators for current and speed.

D. Electrical Interference:

1. The VFD shall be designed to minimize harmonic distortion and radio frequency interference induced into the building distribution systems. IEEE-519, Section 8.3.2, recommends that total harmonic voltage distortion (THD) be limited to five (5%) percent. The FCC Rules and Regulations, Part 15, Subpart J, Class A, proposes limits on Radio Frequency Interference (RFI) levels. The supplier shall provide the owner with data showing the levels of THD and RFI produced by the VFD. The University Project Engineer shall provide the appropriate short circuit current or source impedance rating for calculating THD. Where the cited IEEE and FCC guidelines are not met, filters shall be offered as an option.
(not included in the base price). However, the manufacturer must have available the required filtration to meet the above guidelines.

E. Shop Tests

1. The VFD equipment shall be tested according to IEEE guidelines, and any further standard tests necessary to assure conformance to specification requirements.
2. Copies of all test reports shall be available.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-mounted VFD shall be bolted to angle iron or channel sills on a six (6) inch tall concrete pad furnished by the installer. Sills shall be embedded in the concrete pad flush with the finished surface and level in all directions. Wall-mounted units shall be secured using 1-5/8 inch by 1-5/8 inch by twelve (12) gage unistrut or equivalent. Install drive with a minimum 3-inch clearance all around.

B. Conduit stubs for interconnected VFD cables and remote signal cables shall be located and terminated in accordance with the drive manufacturer's recommendations.

C. Field-installed interior wiring shall be neatly grouped by circuit and bound by plastic tie wraps. Circuit groups shall be supported such that circuit terminations are not stressed.

D. Power wire from VFD output to load shall be shielded cable designed for VFD use. Cable specification to be submitted for approval.

E. Install in-line reactors on the line-side of the VFD as necessary.

F. For installations with 50-ft or more of cable between the VFD and load, provide load reactors/filters.

3.2 FIELD QUALITY CONTROL

A. Startup and Field Tests

1. The supplier shall include with the bid a manufacturer certified service engineer to provide factory startup and testing. This time will be used to ensure proper connection and functioning of the equipment prior to startup and to train owner personnel in the use of the equipment.

2. Supplier shall demonstrate trouble-free, stable operation for conditions of starting, full load, three-quarter load, half load, quarter load, no load, and intermediate loads. Tests shall be in presence of the University Project Engineer.
3. Tests shall include 100 hours of operation under load to demonstrate adequacy of equipment for thermal and voltage stresses. Continual supervision is not necessary but manufacturer shall verify integrity of equipment after 100-hour test.

B. Parts and Service Requirements

1. The supplier shall provide twenty-four (24) hour response to field service needs, and shall indicate the location of the service technician center nearest to the owner's site. The above facility shall be fully qualified and technically capable in all aspects of servicing the VFD.
2. The supplier shall clearly state and give cost information for any repair services not included under the warranty.

END OF SECTION