UNIVERSITY OF MICHIGAN
ARCHITECTURE, ENGINEERING AND CONSTRUCTION

ARCHITECTURE & ENGINEERING
326 East Hoover, Mail Stop B
Ann Arbor, MI 48109-1002
Phone: 734-764-3414
Fax: 734-936-3334

BuildingName
The Description of the Project
P00000000 0000

SPECIFICATION DIVISION 22

NUMBER SECTION DESCRIPTION

DIVISION 22 PLUMBING
SECTION 220514 - VARIABLE FREQUENCY DRIVES

END OF CONTENTS TABLE

DIVISION 22 PLUMBING
SECTION 220514 - VARIABLE FREQUENCY DRIVES

REVISIONS:

OCTOBER 2008: REVISED TO ADD TOTAL HARMONIC DISTORTION LIMITS, SUBMITTAL REQUIREMENTS, PID CONTROLLER, TIME CLOCK, AND MISC. OTHER CORRECTIONS AND CLARIFICATIONS BY D. KARLE FOR HVAC MECH TECH TEAM.

3-11-09: DELETE REQUIREMENT FOR MOTOR-ON-VFD PILOT LIGHT, DRIVE FAILURE PILOT LIGHT; CLARIFY REQUIREMENT FOR RUN PERMISSIVE, POWERED RUN MODE, AND POWERED RUN REQUEST CIRCUITS. BY D. KARLE FOR HVAC MECH TECH TEAM.

6-8-09: ADDED: RELAYS TO BE PLUG-IN STYLE, MAIN AND INVERTER DISCONNECT TO BE ACCESSIBLE W/O OPENING CABINET, FUSES TO BE IN FUSE BLOCKS. D. KARLE FOR HVAC MECH TECH TEAM.

10-15-09: ADDED: REQUIREMENT THAT WIRES ON THE SUBMITTAL DIAGRAMS SHALL BE LABELED WITH AN IDENTIFIER AND THAT WIRES BE CORRESPONDINGLY TAGGED IN THE DRIVE CABINET. D. KARLE FOR HVAC MECH TECH TEAM.

5-9-11: ABB ADDED AS APPROVED MFR. PER HVAC MTT (D.KARLE).

9-10-12: ADDED REQUIREMENT THAT DRIVE BE IN A NEMA 1 OR NEMA 3R ENCLOSURE. D. KARLE FOR HVAC MTT.

01-24-13: ADDED REQUIREMENT AND EDITOR NOTE FOR SHORT CIRCUIT CURRENT RATING.

08-2017: GENERAL REVISION TO REDUCE FEATURES PER HVAC MTT. C. DUVALL, D. KARLE.

PROVIDE A COPY OF THIS SECTION TO THE ELECTRICAL ENGINEER FOR COORDINATION. INDICATE LOCATION OF VFD IN MECHANICAL PLANS AND ENSURE IT IS SHOWN IN ELECTRICAL PLANS. INCLUDE VFD SCHEDULE. SPECIFY 480V IN LIEU OF 208V WHERE EVER POSSIBLE, ESPECIALLY WHEN POWER SOURCE ALSO FEEDS COMPUTERS. ON RETROFIT PROJECTS, BE SURE THAT EXISTING MOTOR IS COMPATIBLE WITH THE NEW VFD.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

INCLUDE PARAGRAPH 1.1.A AND B IN EVERY SPECIFICATION SECTION. EDIT RELATED SECTIONS 1.1.B TO MAKE IT PROJECT SPECIFIC.

A. Drawings and general provisions of the Contract, Standard General and Supplementary General Conditions, Division 1 Specification Sections, and other applicable Specification Sections including the Related Sections listed below, apply to this Section.

1.2 SCOPE OF WORK:

A. Provide variable frequency drives (VFD) meeting the requirements contained herein and as indicated in the VFD schedule.

1.3 QUALITY ASSURANCE:

A. VFD shall comply with NFPA 70 (National Electrical Code), IEEE 519, UL 508, NFPA 70, and FCC compliance for Radio Frequency Interference (RFI) and Electro- Mechanical Interference (EMI).

1.4 WARRANTY:

A. Provide a minimum of 3 years parts and labor warranty from the date of final acceptance by the University.

1.5 ACCEPTABLE MANUFACTURERS:

A. Variable speed drives shall be manufactured by one of the following: Danfoss, Toshiba, ABB. VFDs manufactured by parent companies or their subsidiaries are not acceptable.

1.6 SUBMITTAL DATA

A. Submit for approval, the following product data:

1. Dimensions and elevations.
2. Complete product data listing all included features.
3. The electrical rating for each VFD, matched to each piece of driven equipment.
4. Short circuit current (withstand) rating.
5. Project specific wiring diagrams indicating:
   a. Line/load connection points
   b. Main input and inverter input disconnect switches
   c. VFD/bypass switch circuit
   d. Fusing/circuit breakers
   e. Auxiliary control transformer
   f. Local/remote circuit
   g. Hand-off-auto circuit
   h. Safety interlock, run permissive, and drive initiated external circuits
   i. Analog inputs and outputs
   j. Pilot lights
   k. Each wire on the wiring diagram shall be labeled with a distinct wire identifier.
6. VFD panel face diagram indicating the location of the main and inverter disconnect switches, local/remote and H-O-A switches, VFD/bypass switch, pilot lights, digital display, keypad, and any other face mounted device, along with the panel face labeling.

PART 2 - PRODUCTS

HOSPITAL PROJECTS MAY REQUIRE 18 PULSE DRIVES. REVIEW THE HOSPITAL DESIGN GUIDELINES AND CONSULT WITH HOSPITAL FACILITIES AND ADJUST THE BELOW PARAGRAPH IF REQUIRED.

2.1 GENERAL:

A. Provide minimum 6 pulse PWM type drives.

B. VFDs designated for installation indoors shall have enclosures rated NEMA 1. VFDs designated for installation outdoors shall have enclosures rated NEMA 3R minimum. The same NEMA requirements shall be provided for enclosures housing a bypass or any other accessory.

C. The VFD shall be capable of operation at the maximum ambient temperature at the drive location without derating.

D. All device ends and termination points including fuse blocks, input/output wiring lugs, terminal strips, transformers, contactors, and other electrical devices inside the panel shall be provided with insulated "finger proof" covers to prevent contact with electrical energy when the front panel door is open.

E. All relays shall be plug-in style base.

COORDINATE WITH THE ELECTRICAL ENGINEER AND INSERT THE REQUIRED MINIMUM SHORT CIRCUIT CURRENT RATING.

F. The VFD (including bypass and other accessories) shall have an overall short circuit current (withstand) rating of _____ amps symmetrical minimum, and shall be marked with its short circuit current rating in compliance with UL.

G. The unit, including all specified accessories, shall have a minimum efficiency of 85 percent at any speed from 50 to 100 %. The unit shall have a power factor of 0.9 or higher when operating at any speed from 50 to 100%.

H. The VFD shall be variable torque type and shall provide full motor torque at any operating speed from 40% to 100%. Provide constant torque type for constant torque applications, including but not limited to energy recovery wheels. It is the responsibility of the VFD supplier to determine if the driven load requires a constant torque type VFD.

I. Provide the drive with a main input disconnect switch, accessible without opening the drive cabinet, equipped with current limiting fuses and fuse rejection clips, or with circuit breakers. When the drive is equipped with a bypass, this disconnect shall control power to both the load and the VFD. All other fuse blocks with current limiting fuses installed shall be equipped with fuse rejection clips. It shall be possible to padlock the disconnect switch in the off position.

SPEC EDITOR: BYPASS MAY BE OMITTED FOR FULLY REDUNDANT EQUIPMENT. SEE U-M DESIGN GUIDELINES FOR FURTHER INFORMATION. DO NOT INDISCRIMINATELY REQUIRE BYPASSES. INSTALL A BYPASS FOR ALL LABORATORY FANS.

J. Provide a factory mounted and wired manual bypass device as scheduled. The bypass device shall allow the load to run across-the-line while electrically isolating the VFD so that maintenance can be performed on the drive components. Provide the necessary electronics to avoid audible noise generated from motor due to frequency change. The unit shall not increase the motor audible noise by more than 3 dB above the motor's across the line noise at any motor speed from 50 to 100 %.

K. The unit shall include self diagnostics with a digital display that identifies fault conditions and simplifies trouble shooting. Fault indication shall be retained even after a power outage or an input over-current protective device trip.

L. Unit shall be provided with RFI/EMI filters.

M. Unit shall be UL, CSA or ETL labeled.

N. VFD shall include current sensors on all three output phases to accurately measure motor current.

SPEC EDITOR: THE ENGINEER MUST SPECIFY AS PART OF THE DIVISION 26 ELECTRICAL TESTING SECTION THAT THE CURRENT AND VOLTAGE THD BE MEASURED AT EACH DRIVE.

O. Provide minimum 3 percent AC input line reactors and/or minimum 5 percent DC link reactors to limit the maximum current total harmonic distortion (THD) to not more than 100% of the VFD input current waveform at any VFD operating speed from 20% to 100%. Reactors shall be integral to the VFD. The reactor(s) shall not be active when the drive is in bypass mode. If testing reveals the maximum THD is exceeded, the manufacturer shall provide and install additional reactors at no cost to reduce the THD to within these specified limits.

P. The unit shall have a dedicated terminal block for all external inputs and outputs.

Q. Provide factory mounted and wired 115V, 1 phase, 60 Hz control power transformer sized for handling an additional 30 VA inductive load. Limit fuse size for the control transformer to 3 amps maximum.

SPEC EDITOR: 480V IS OUR STANDARD VOLTAGE FOR VFDS, EVEN IF POWER AVAILABLE IS 208V/3P. IN THOSE CASES, WORK WITH THE ELECTRICAL ENGINEER AND PROVIDE A STEP-UP TRANSFORMER. IF MOTOR MUST USE 208V FOR A SPECIFIC APPLICATION, COORDINATE WITH ELECTRICAL ENGINEER AND PROVIDE A DESIGN THAT SEGREGATES VFD FROM ANY FEEDER CIRCUIT OR PANEL THAT ALSO FEEDS COMPUTERS OR ELECTRONIC EQUIPMENT.

~~R.~~ The VFD voltage and phase shall match the line and load voltage and phase indicated on the drawings.

2.2 CONTROL FEATURES:

A. The VFD shall be provided with the following control features:

1. Factory mounted and wired Hand-Off-Auto selector switch that allows local or remote starting or stopping of the drive. Separate start and stop buttons, electronic circuits that "virtually" provide this capability, or other alternative devices are not acceptable.
2. Factory mounted and wired VFD-Bypass switch, if bypass device is provided.
3. Factory mounted and wired Local-Remote speed control switch, that allows either local or remote control of the drive speed. Key pad buttons are also acceptable provided that permanently labeled, dedicated buttons are provided for the local and the remote speed control functions.

4. Inverter input disconnect switch, accessible without opening the drive cabinet, if bypass device is provided.
5. Manual speed potentiometer or keypad control, for local speed control with the Local-Remote speed control switch in the Local position.
6. A VFD controller with a man/machine interface (MMI)consisting of a back-lit liquid crystal (LCD) display and labeled push buttons or a touch screen. The MMI shall provide access to view and set all drive functions, including the following required functions:
   a. Adjustment of drive speed at the MMI, when the VFD controller is set for local control.

7. The controller/MMI shall display, at minimum, the following parameters:
   a. Motor speed indication including RPM, GPM, CFM units.
   b. kWh
   c. Power
   d. Horsepower
   e. Output amperage, per phase
   f. Output voltage
   g. Output frequency
   h. Input reference signal
   i. Speed and start/stop controlled locally or remotely
   j. Fault warning messages
   k. Drive fault cause
   l. Acceleration and deceleration rate
   m. Frequency lock-outs
8. The VFD shall accept an input reference signal, 0-10 Vdc analog or 4-20 mA analog, as indicated in the VFD schedule, for remote speed control with the Local-Remote speed control switch in the Remote position. Provide input signal isolation to isolate input signal ground from VFD internal control ground.
9. A remote start/stop contact input that functions in the automatic mode only.
10. A safety interlock circuit that functions in drive and by-pass modes.
11. A run permissive circuit, separate from the safety interlock circuit, which prevents motor operation whether in drive or bypass mode. This circuit, via the customer's external contact device, signals the motor may run, provided the safety interlock contact(s) is made. A typical application would be for a time delay before motor start to allow some external event to occur. The run permissive circuit shall be jumpered from the factory.
12. Provide the following drive initiated external circuits:
    a. Powered run mode: A circuit that is powered after the motor is started in drive or by-pass modes.
    b. Powered run request: A circuit that is powered whenever the drive safety interlock contact(s) are closed, and the drive H-O-A is in hand, or the drive H-O-A is in auto and the remote start/stop contact is closed.
13. A standard USB port for direct connection of a Personal Computer (PC) to the VFD. The manufacturer shall provide PC software to allow complete setup and access to the VFD through the USB port. It shall be possible to communicate to the VFD through this USB port without interrupting VFD communications to the building management system

14. An integral PID controller that, when activated, controls drive speed to maintain a programmed setpoint based on a remote analog input signal.
    a. The VFD shall be able to apply a scaling factor to the input signal.
    b. The VFD shall be able to calculate the square root of the input signal so that a pressure sensor can be used to measure flow.
15. A real-time clock shall be an integral part of the VFD.
    a. It shall be possible to use this to display the current date and time on the VFD's display.
    b. The clock shall include a time clock function with 7 day programmability and a minimum of four programmable time periods per day, with individually selectable ON and OFF functions. The time clock function shall be programmable to control start/stop functions, constant speeds, PID parameter setpoints and output relays. The time clock function shall be programmable through the controller display and keypad, or by included software that allows programming via a PC and a USB connection.
16. VFD shall be capable of starting a coasting load.
17. VFD shall automatically attempt to restart a minimum of three (3) times during an adjustable time period of no less than 30 seconds after shutting off for any reason, except for short circuit or motor overload.
18. The VFD shall have adjustable motor acceleration and deceleration rates.
19. The VFD shall have the ability to lock-out a minimum of four critical frequency ranges to prevent the VFD from operating the load at a speed that causes vibration in the driven equipment.
20. Provide the ability to program a minimum of 12 preset speeds, selected by the drive, when started by a digital input.
21. Provide a minimum of one 4-20 mA analog output signal selectable to proportionally indicate drive output frequency, current, or power, or to indicate the VFD input reference signal, for monitoring by DDC

THE BELOW FEATURES ARE GENERALLY NOT REQUIRED. IF REQUIRED UNHIDE THE TEXT BELOW.

22. Provide the following additional contacts:
    a. Provide an additional set of N.O. contacts on the VFD-Bypass switch that close when the switch is set to Bypass.
    b. Provide one normally open and one normally closed auxiliary contacts to actuate when the motor is started in any mode.

2.3 INDICATORS:

A. Indicating lamp for "POWER AVAILABLE" and for "MOTOR ON BYPASS". Lights shall be LED type.

2.4 SAFETIES:

A. Provide status lights or digital display indication at the MMI of the cause of any shutdown.

B. The VFD shall be provided with the following safety features:

1. VFD over voltage and under voltage protection and protection against temporary power outages.
2. VFD over temperature protection.
3. Motor over temperature protection per NEC 430.126(A)(2).
4. Short circuit and ground fault protection.
5. Separate motor overload protection functional in by-pass and normal operation. For VFD's controlling multiple motors, provide overload protection for each motor.
6. Adjustable current limiter.

2.5 LABELING:

A. Provide engraved plastic labels permanently attached to the VFD panel face indicating the function of all switches and indicators, and the equipment served.

B. Tag all wiring in the drive. Tag nomenclature shall match the corresponding wire identification nomenclature indicated on the approved drive submittal.

C. For VFDs serving smoke purge, stair pressurization, or other smoke control systems, include an engraved permanently attached red faced label, minimum 6" x 6", with the following nomenclature: CAUTION: THIS VFD IS PART OF A LIFE SAFETY SMOKE CONTROL SYSTEM. NOTIFY U-M DEPARTMENT OF PUBLIC SAFETY PRIOR TO ANY CHANGE OR MAINTENANCE ACTIVITY TO THIS DRIVE.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Unit installation, including mounting and supports, and wiring to motor shall be by the Electrical Contractor, in compliance with Division 26. Coordinate with the Electrical Trades and Control Trades as required.

B. Install the VFD as close as possible to the motor. The load side power cables to the motor shall be kept as short as possible and shall not be run in the same conduit as the line side power cables. Control wiring shall be in separate conduit from power wiring. Where applicable, control wires from the motor disconnect early break contacts may be installed with the motor power wiring.

C. Protect the unit from dirt, dust, water and physical damage prior to and during construction. If the inside of the unit becomes dirty or dusty before acceptance by the University, it shall be thoroughly cleaned by the unit manufacturer at the contractor's expense.

3.2 CHECK, TEST AND START:

A. Provide the services of a factory trained and certified technician to supervise check, test and start. The contractor shall notify U of M representative 5 days in advance of the start-up.

3.3 TRAINING:

SPEC EDITOR: TRAINING IS NOT GENERALLY REQUIRED FOR VFDS WITH WHICH PLANT IS ALREADY FAMILIAR, BUT MAY BE REQUIRED FOR NEW MODELS. CONSULT THE U-M DESIGN MANAGER REGARDING IF TRAINING IS REQUIRED.

A. Conduct a minimum of 4 hours training for maintenance staff on operation, programming and service of VFDs. Training shall be conducted by a factory trained service technician.

B. Training shall not be performed until system is operational and functional and two (2) weeks after receiving approved job specific technical manuals.

END OF SECTION 220514