

SECTION 26 29 23 - VARIABLE FREQUENCY MOTOR CONTROLLERS

PART I - GENERAL

1.1 RELATED UI STANDARDS

- A. *Section 260519 – Conductors and Cables: VFD Cable*
- B. *Section 260553 – Identification of Electrical Systems*
- C. *Section 266000 – Common Motor Requirements*

1.2 REFERENCES

- A. NEMA ICS 3.1 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Variable Frequency Drive Systems
- B. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
- C. UL Approved
- D. IEE Standard 519
- E. UL 508A - Industrial Control Panel

1.3 SUBMITTALS

- A. Shop drawings shall be provided that indicate the exact electric wiring diagram for each VFD, which includes a minimum of 2 circuit diagrams (power and control schematic of all VFD functions and a control ladder logic diagram). These drawings shall be delivered and approved by the AE and the Owner in writing before the VFD's are released for production and shipped to the job site.
- B. Installation, maintenance and operating instructions shall be provided for each VFD.
- C. Provide a troubleshooting guide to help the building operator determine what steps must be taken to correct any problem that may exist in the systems.
- D. An Electronic copy ("Auto Cad" compatible) of the final schematic shall be provided to the University of Illinois. Final schematics are the responsibility of the AE after final field adjustments have been made and documented by Contractor. See Division 1 for Drawing and as-built requirements.
- E. The Manufacturer's representative shall create an Electronic copy of the final parameter settings for each VFD during the startup process. These final parameter files must be turned over to Owner before Final Completion. Manufacturer's representative is responsible for supplying a PC and cables to accomplish the parameter file creation.
- F. Two (2) copies of the Final wiring schematic shall be installed in the Power and Control Interface Box. The schematics shall be placed in a plastic sleeve for protection. The schematic shall clearly indicate wire terminal numbers for each termination.
- G. When Bypass option is required, provide the Motor Full-Load Amperage and the Motor Overload Relay heater size installed or adjusted setting, before Final Completion. Incorrect heaters or electronic relay settings are not allowed.
- H. HARMONIC ANALYSIS SUBMITTAL – each project A/E shall prove compliance to IEEE 519-1992: Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

1. Project A/E will list which VFDs will require Harmonic Filters in the Bid documents.
2. If the A/E determines that some VFDs require Harmonic Filters, the VFD submittal shall include harmonic calculations made in accordance with IEEE 519-1992 showing that the specified total harmonic voltage and current limits are met.
3. The total harmonic distortion (THD) created by the VFDs shall be 5% or less with each individual harmonic limited to 3%. If the THD is within the requirements above, then a 3% line reactor will only be required. If the THD exceeds the 5% limit, additional equipment shall be required to reduce the harmonics to an acceptable level.
 - a. If the A/E states in the Bid documents that input filters are required, the VFD manufacturer shall be responsible for: sizing the filters for each drive, providing wiring schematics to the contractor and for commissioning of the VFD and the filter once installed.
 - b. See Part 2 of this Section for Harmonic Filter requirements.
4. Calculations shall assume worst case system conditions and 50% transformer loading at the point of common coupling. System one lines, transformer data, standby generator data, and primary fault current data required to make these calculations shall be included in the system short circuit study and shall be obtained by the electrical contractor. The submittal shall include the following information:
 - a. All input data and assumptions.
 - b. All calculations and computer printouts used in the analysis, including input documentation.
 - c. All calculations shall be in accordance with IEEE 519 with all drives at rated speed. The point of common coupling shall be the secondary side of the building distribution transformer. These calculations shall be done with the transformer loaded to no more than 50% of its normal capacity. These calculations shall be done with all new and existing drives running and with any additional non-linear loads.

1.4 OPERATION AND MAINTENANCE DATA

- A. Include instructions for starting and operating VFD, and describe operating limits, which may result in hazardous or unsafe conditions.

1.5 QUALIFICATIONS

- A. Manufacturer must have a minimum of 10 years of documented experience, specializing in variable frequency drives.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Accept VFD on site in original packing. Inspect for damage.
- B. Store in a clean, dry space. Maintain factory wrapping, or provide an additional heavy canvas or heavy plastic cover, to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully, in accordance with manufacturer's written instructions, to avoid damage to components, enclosure, and finish.

1.7 WARRANTY

- A. VFD's shall be guaranteed by the manufacturer for 2 calendar years from date of certified start -up. The vendor, at his expense and without extra charge to the University, and within a reasonable period of time after being contacted by the University, shall provide labor and

material to repair or replace any defects in material and workmanship on the VFD, which develop or appear during this 2-year period.

PART 2 - PRODUCTS

LOW VOLTAGE VARIABLE FREQUENCY DRIVES

2.1 MANUFACTURERS

A. VFD and enclosure shall be:

1. Z1000 Configured type, manufactured by Yaskawa America, Inc.
2. ACS800 Configured type, manufactured by ABB, Inc.
3. PowerFlex 700 Configured Package Drives, manufactured by Allen-Bradley, Inc.

2.2 DESCRIPTION

- A. Provide enclosed configured variable frequency drives suitable for operation at the current, voltage, and horsepower indicated on the schedule. Conform to requirements of NEMA ICS 3.1.

2.3 RATINGS

- A. VFD must operate, without fault or failure, when voltage varies plus 10% or minus 15% from rating, and frequency varies plus or minus 5% from rating
- B. Displacement Power Factor: 0.98 over entire range of operating speed and load
- C. Service Factor: 1.0
- D. Operating Ambient Temperature: NEMA 1 (IP20): -10°C to 40°C (14°F to 104°F)
- E. Humidity: 0% to 95% non-condensing
- F. Minimum Efficiency: 96% at half speed; 98% at full speed
- G. Starting Torque: 100% starting torque shall be available from 0.5 Hz. to 60 Hz
- H. Overload capability: 110% of rated FLA (Full Load Amps) for 60 seconds; 150% of rated FLA peak
- I. Controlled speed range of 40:1
- J. The VFD's shall include EMI/RFI filters
- K. VFDs must be suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical amperes

2.4 DESIGN

- A. VFD shall employ microprocessor based inverter logic, isolated from all power circuits.
- B. VFD shall include surface mount technology with protective coating.
- C. VFD shall employ a PWM (Pulse Width Modulated) power electronic system, consisting of:
1. Input Section:
 - a. VFD input power stage shall convert three-phase AC line power into a fixed DC voltage via a solid state full wave diode rectifier, with MOV (Metal Oxide Varistor) surge protection.
 - b. A minimum of 5% DC bus impedance to minimize reflected current.
 2. Intermediate Section:

- a. DC bus as a supply to the VFD output Section shall maintain a fixed voltage with filtering and short circuit protection.
 - b. DC bus shall be interfaced with the VFD diagnostic logic circuit, for continuous monitoring and protection of the power components.
3. Output Section:
- a. Insulated Gate Bipolar Transistors (IGBTs) shall convert DC bus voltage to variable frequency and voltage.
 - b. The VFD shall employ PWM sine coded output technology to power the motor.
- D. The VFD must be rated for operation at a carrier frequency of 5 kHz to satisfy the conditions for current, voltage, and horsepower as indicated on the equipment schedule.
- E. VFD shall have an adjustable carrier frequency, from 1 kHz to 12.5 kHz (Above 250HP from 1kHz to 5kHz)
- F. VFD Must include an adjustable dynamic noise control for quiet motor operation
- G. VFD shall have Building Automation System (BAS) protocols for network communications; BACnet and Modbus RTU. These protocols shall be accessible via a RS-422/485 communication port. A compatible adapter/card shall be provided for the approved protocol to allow integration of the VFD to the building control system. Verify which protocol is required for the project before VFD order is placed.
- H. VFD shall include two independent analog inputs. Selectable for either 0-10 VDC or 4-20 mA. Either input shall respond to a programmable bias and gain.
- I. VFD shall include a minimum of seven multi-function digital input terminals, capable of being programmed to determine the function on a change of state.
- J. VFD shall include two selectable 0-10 VDC or 4-20 mA analog outputs for monitoring, or "speed tracking" the VFD. The analog output signal will be proportional to output frequency, output current, output power, PI (Proportional & Integral control) feedback or DC bus voltage.
- K. VFD shall provide terminals for remote input contact closure, to allow starting in the automatic mode.
- L. VFD shall provide 24 VDC, 150ma transmitter power supply.
- M. VFD shall include at least one external fault input, which shall be programmable for a normally closed contact. These terminals can be used for connection of firestats, freezestats, high pressure limits or similar safety devices.
- N. VFD shall include two programmable form "A" contacts and one fixed "Fault" form "C" contact, capable of being programmed to determine conditions that must be met in order for them to change state. These output relay contacts shall be rated for at least 2A at 120 VAC.
- O. VFD shall include a power loss ride through capable of 2 seconds.
- P. VFD shall have DC injection braking capability, to prevent fan "wind milling" at start or stop, adjustable, current limited.
- Q. VFD shall have a motor preheat function available to prevent moisture accumulation in an idle motor.
- R. VFD shall include diagnostic fault indication, time and date stamped faults storage and heat sink cooling fan operating hours.
- S. VFD shall have a digital operator with program copy and storage functions to simplify set up of multiple drives. The digital operator shall be interchangeable for all drive ratings.

- T. VFD shall include a front mounted, sealed keypad operator, with an English language illuminated LCD display. The operator will provide complete programming, program copying, operating, monitoring, real time clock and diagnostic capability.
- U. VFD plain language display shall provide readouts of; output frequency in hertz, PI feedback in percent, output voltage in volts, output current in amps, output power in kilowatts, D.C. bus voltage in volts, interface terminal status, heat sink temperature and fault conditions. All displays shall be viewed in an easy-to-read illuminated LCD.
- V. VFD unit shall include the following meters to estimate use of energy:
1. Elapsed Time Meter
 2. Kilowatt Meter
 3. Kilowatt Hour Meter
- W. VFD shall include a user selectable PI control loop, to provide closed loop set point control capability, from a feedback signal, eliminating the need for closed loop output signals from a building automation system. The PI controller shall have a differential feedback capability for closed loop control of fans and pumps for pressure, flow or temperature regulation in response to dual feedback signals.
- X. VFD shall have an independent, PI loop that can be used with a second analog input that will vary the VFD analog output and maintain a set point of an independent process (valves, dampers, etc.)
- Y. VFD shall include loss of input signal protection, with a selectable response strategy including speed default to a percent of the most recent speed.
- Z. VFD shall include electronic thermal overload protection for both the drive and motor. The electronic thermal motor overload shall be approved by UL. If the electronic thermal motor overload is not approved by UL, a separate UL approved thermal overload relay shall be provided in the VFD enclosure. Whenever a VFD supplies 2 or more motors, the VFD enclosure shall have individual overload protection for each motor, per NEC, mounted inside the VFD enclosure. Each individual overload shall be wired into the VFD safety control circuit.
- AA. VFD shall include the following program functions:
1. Critical frequency rejection capability: 3 selectable, adjustable dead bands.
 2. Auto restart capability: 0 to 10 attempts with adjustable delay between attempts.
 3. Stall prevention capability.
 4. Bi-directional "Speed search" capability, in order to start a rotating load.
 5. Heat sink over temperature speed fold back capability.
 6. Terminal status indication.
 7. Program copy and storage in a removable digital operator.
 8. Programmable security code
 9. Current limit adjustment capability, from 30% to 200% of rated full load current of the VFD.
 10. Input signal or serial communication loss detection and response strategy.
 11. Anti "wind-milling" function capability.
 12. Automatic energy saving function.
 13. Under torque/Over torque Detection.
 14. Fan failure detection and selectable drive action.

15. Seven preset speeds.
16. VFD shall include factory settings for all parameters, and the capability for those settings to be reset.
17. VFD shall include user parameter initialization capability to re-establish project specific parameters.

BB. Any relays installed in the VFD enclosure shall be gold-contact, with a Minimum Low Energy Permissible Load of 50mW, 25V or less, Allen-Bradley model 700-HC14A1-4, or approved equal. Relay shall use a plug-in socket mount, with finger-safe terminals, Allen-Bradley 700-HN103, or equivalent. Verify who supplies the relays on each project.

CC. Configured Drive will be provided with a signal Converter/Isolator wired to the Analog Input. Isolation Modules shall be PR Electronics Model 4116 with 4501 LCD display or *[Note to AE: Include 2 additional Owner-approved manufacturers.]*

DD. Configured Drive will include a terminal strip for all field-installed control wires to terminate to, wired per UI Standard VFD control diagram.

EE. All control fuses shall be Class CC.

2.5 PRODUCT OPTIONS

[Note to the Consulting Engineer; See Appendix One to Select Additional Options to be Applied to a Specific Project]

The following options shall be included on ALL variable frequency drives:

1. Input Circuit Breaker or Heavy Duty Switch
2. Input High-Speed Fuses
3. 3% Input Reactor
4. Cover Mounted Speed Potentiometer
5. Cover Mounted HAND-OFF-AUTO selector switch
6. 200VA Control Transformer, with Class CC fuse protection on 2 input lines, and 1 output line

2.6 FABRICATION

- A. All standard and optional features shall be included in a single NEMA 1, plenum rated enclosure with a UL certification label.
- B. Enclosure shall be large enough to enclose all Product Options, plus allowance for field-installed control components. 8" long, 6" wide, 6" high minimum.

2.7 LONG LEAD FILTER, IF REQUIRED

- A. Install a dV/dT filter for motor lead lengths between VFD and motor exceeding 150feet for 480V motors. (Not required for 208/230 VAC motors). VFD Carrier Frequency shall be set to the lowest allowable setting which ambient sound level will allow, preferably 1-2 kHz.
- B. Filter manufactured by TCI (Trans-Coil. Inc. - Milwaukee, WI), part number VLK**a01EX, or pre-approved successor, where ** is equal to or greater than the VFD Output Full Load Rated Amps. Filter shall be in a UL listed enclosure.
- C. The dV/dT Filter shall be warranted for a minimum of one year.
- D. Locate filter within 10 (wire) feet from the VFD that it services.
- E. Set the VFD carrier frequency to 8 kHz or below and operating frequency to 60 Hz or below. 2Hz carrier frequency is recommended.

2.8 HARMONIC FILTER, WHEN REQUIRED

- A. Design Engineer will determine before a project is bid as to the need for Harmonic Filters. If needed, they shall be listed on the VFD Schedule.
- B. If a harmonic filter is required for the line side of a VFD, it shall be a TCI (Trans-Coil. Inc. - Milwaukee, WI), Series HG7 Harmonic Guard Series, Drive Applied Filter, or approved equal.
- C. The filter is required to be removed from the line power whenever the VFD is not running. This shall be accomplished by a contact at the VFD/Power Interface Box, which will close when the VFD is running. Filters that do not disconnect from the line voltage when the VFD is not running will not be accepted.
- D. The filter shall be:
 - 1. UL Listed (Industrial Control Panel)
 - 2. In a UL Type 1 enclosure
 - 3. Have a 3-Year warranty from date of startup
- E. The Filter shall be of the following model number for a 480V VFD: HGxxxAW01XM, where xxx represents the horsepower of the VFD, or pre-approved successor.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that surface is suitable for VFD installation.
- B. Do not install VFD until the building environment can be maintained, within the service conditions required by the manufacturer.

3.2 INSTALALTION

- A. Install VFD where indicated, in accordance with manufacturer's written instructions and NEMA ICS 3. Install VFD with proper clearance as shown in NEC Article 110.
- B. No conduits will be allowed to enter the top of the VFD enclosure without written approval of the Owner.
- C. Tighten accessible connections and mechanical fasteners to manufacturers torque specifications, after placing VFD.
- D. Provide a nameplate label on each VFD with the following information:
 - 1. Main label identifying the five-digit UI Building Number and the motor served by the VFD. Example: 00192-VFD-AHU1. The label shall be yellow background, 2" high, with black lettering of 3/4 inch.
 - 2. The VFD enclosure shall also be labeled to indicate the power source, including Panel Name, Circuit numbers, and the location of the panel. Example: Fed from Panel DP-1, Circuits 32, 34, 36, in Room 194B.
- E. All equipment such as relays, isolation devices, etc. mounted within the VFD enclosure shall be securely fastened to a DIN Rail, or by screws. (Velcro or other such fasteners are not acceptable).
- F. Line, load and control wiring shall be installed in a minimum of 3 separate conduits. Wiring used for low voltage control or monitoring (analog or digital) shall not be run within the same conduit as line or load wiring. Note: Control wiring is considered anything other than line or

load wiring. If there is 120V control wiring, it shall be installed in a separate conduit from the other low voltage control wiring.

- G. All conductors from the VFD to the motor shall be by a VFD Tray Cable. See UI Standard 260519 *CONDUCTORS AND CABLES* for more information on the cable types approved.
- H. When a Safety Switch is installed between the VFD and the motor, it shall contain an Auxiliary Contact. The Aux Contact shall be wired into the VFD safety Circuit to shut the VFD off before the switch opens, and not allow it to start before the Safety Switch is closed. Control wires shall NOT be installed in the same raceway as the Motor Conductors.

3.3 FIELD QUALITY CONTROL

- A. Field inspection, startup, and testing to be performed by a Manufacturers Certified Representative.
- B. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.
- C. The VFD Manufacturer Certified Startup Representative shall make an inspection of the equipment including those components necessary to the direct operation of the system. All test and report costs shall be borne by the supplier. The inspection technician shall prepare a checkout report, and a copy of the original VFD startup forms shall be submitted to the Owner, and a copy shall be registered with the equipment manufacturer. The report shall include, but not be limited to:
 - 1. A complete list of equipment installed and wired.
 - 2. Indication that all equipment is properly installed and functions and conforms to these Specifications.
 - 3. Physical tests of each individual device. This includes voltage phase-to-phase on input and output, and current on each phase of input and output conductors.
 - 4. When Bypass option is required, provide written copy of Motor Nameplate Full-Load amperage, Overload Heater setting or model number, and manufacturers' heater chart.
 - 5. Serial numbers, locations by device and model number for each installed device.
 - 6. That wiring connections to all equipment shows the installer observed the National Electrical Code.
 - 7. That the supervisory wiring of the equipment connected to a supervised circuit is operating and has met the satisfaction of inspecting officials.
 - 8. Technicians name, certificate number and date.
 - 9. The manufacturer shall supply all technical assistance with respect to any changes necessary to ensure a complete, workable system. During the period of inspection by the manufacturer, the electrical Contractor shall make available electricians for whatever changes deemed necessary by the manufacturer at the Contractor's cost.
 - 10. After system installation and after initial system test is completed, equipment shall be demonstrated to satisfy the requirements of this Specification prior to the Operational Acceptance Test:
 - 11. Operational Acceptance Test: An operational test of not less than 30 consecutive days shall be conducted on the complete and total installed and operational system to demonstrate that it is functioning properly in accordance with all requirements of this Specification. The correct operation of all equipment shall be demonstrated as well as the operation and capabilities of all sequences, reports, diagnostics, and all other software

3.4 MANUFACTURERS FIELD SERVICES

- A. The Manufacturer shall provide local, in-house warranty and service backup. Factory-trained personnel specifically trained for electrical component maintenance and troubleshooting must perform this service backup.
- B. The VFD Manufacturer shall supply the Name, Business Address, and Phone Number of the Designated Service Supply, which will be performing any Warranty Service work. This information must accompany the VFD Submittals.
- C. VFD manufacturer shall have the following available:
 - 1. Service Engineer
 - 2. Training/Service Schools
 - 3. 24-hour phone service

3.5 USER AGENCY TRAINING

- A. Training shall be provided for users if an approved manufacturer or drive series is new to the university or if user deems training necessary during the project design phase. If training is required, then the system manufacturer or authorized distributor shall provide training for users. The initial session to occur when Owner accepts the system. Follow-up sessions shall occur within 1 year after acceptance. All training sessions shall be independent (not concurrent). The initial and review sessions shall consist, minimally, of instruction as follows:
 - 1. Initial Session: On Site Personnel Training including classroom as well a mechanical room for hands-on portion:
 - 2. Four hours of instruction including an overview of the system and its capabilities, what to do in case of alarm or trouble.
 - 3. Four hours of instruction as in both items above in addition to maintenance instruction on each type of device connected to the system, all modules involved in the control panel and all aspects of user-accessible programming.
 - 4. Personnel Factory Training: 4 workers to 3 day training school at manufacturing facility. Training shall include, but not be limited to: product features/design, application/start-up programming, and service/component replacement procedures. Successful bidders are required to conduct both on-site and factory training once in an 18 month window, or sooner if equipment changes significantly. Training shall be at the expense of the manufacturer. Lodging, meals and transportation are an Owner expense.

PART 4 PRODUCTS – MEDIUM VOLTAGE VFD's

[Note to the Consulting Engineer: delete Part 4 if project does not include Medium Voltage VFD's]

4.1 ACCEPTABLE MANUFACTURES

- A. ABB ACS2000 series
- B. Allen-Bradley PowerFlex 7000 Series

4.2 REQUIREMENTS

- A. Power modules shall be rated at line voltage.
- B. The VFD shall be sized for an overload capacity of 110% of rated current for a 1 minute repeated every 10 minutes.
- C. The VFD shall require front access only.
- D. The following components shall be integrated into the VFD system:
 - 1. An integral line reactor

2. An active front end
 3. DC Link with common mode voltage protection
- E. A separate NEMA 1 enclosure for the interfacing devices shall be located next to drive. Separate enclosure shall also contain:
1. Cover Mounted Speed Potentiometer
 2. Cover Mounted HAND-OFF-AUTO selector switch
- F. Terminal Blocks for Input and Output power and common customer connections shall be provided. Customer connections shall be clearly labeled and shall include the following terminals as a minimum and function as follows:
1. 115 VAC power (hot and neutral) from control transformer.
 2. External Fault (Safety or Run Enable) input signal.
 3. "Auto" start signal from Building Automation System.
 4. "Auto" speed reference signal (from Building Automation System).
 5. Motor run status (contact from VFD).
- G. The following spare parts shall be furnished with each medium voltage drive:
1. Three of each type of fuse: Power and Control sizes
 2. Three power modules
 3. One set of control boards
 4. Two sets of air filters

APPENDIX ONE

PRODUCT OPTIONS

[Note to the Consulting Engineer; Select Options to be applied to this Project only when required, Insert in the Appropriate Specification Section]

1. Three-Contactor Manual Bypass shall be provided when indicated by the schedule. VFD and bypass package shall be NEMA 1 rated, fully pre-wired and ready for installation as a single UL listed device. Bypass shall include the following:
 - a. Drive output, and bypass contactors to isolate the VFD from the motor, when the motor is running in the bypass mode. These contactors shall be electrically and software interlocked to ensure safe operation.
 - b. 120 VAC control transformer, with fused primary.
 - c. Electronic motor overload relay, to display motor amps and protect the motor while operating in the bypass mode.
 - d. Disconnect switch, with a pad-lockable through-the-door handle mechanism.
 - e. Control and safety circuit terminal strip.
 - f. Current transformers on the output of the Drive/Bypass package for displaying motor current in both modes of operation as well as verification that the motor is running.
 - g. Provide BACnet and Modbus communication protocols as standard, with the ability to configure controller parameters view controller monitors, control I/O, clear faults and view controller status in both drive and bypass modes.
 - h. Door mounted control panel with; Drive/Bypass selector keys, Hand/Off/Auto selector keys, Normal/Test selector keys, Manual Speed potentiometer.
 - i. Door mounted control keypad with LCD display for "Control Power", "Drive Ready", "Drive Run", "Drive Selected", "Drive Fault", "Drive Test", "Bypass Selected", "Bypass Run", "Motor OL", "Safety Open", "BAS Interlock", "Auto Run", "Auto Transfer", "Emergency Override", "Hand Mode", "Off Mode", and "Auto Mode".
 - j. Drive/Bypass selector keys, to allow switching between the Drive and Bypass mode.
 - k. Hand/Off/Auto selector keys shall provide the following operation and be programmed to operate in any of these modes upon power-up:
 - l. Normal/Test selector keys, to allow VFD trouble shooting while operating in bypass mode.
 - m. Hand Position - The drive is given a start command, operation is via the door mounted speed potentiometer. If in bypass mode, the motor is running.
 - n. Off Position - The start command is removed, all speed inputs are ignored, power is still applied to the drive. If in bypass mode, the motor is stopped.
 - o. Auto Position - The drive is enabled to receive a start command and speed input from a building automation system. If in bypass mode, the motor start/stop is controlled by the building automation system
 - p. Eight Programmable digital inputs (24Vdc, 8mA) shall be provided for Auto Transfer to bypass, Safety Interlock, BAS Interlock, and numerous other bypass specific functions.

- q. Four Programmable form C relays (24Vdc/120 VAC, 2 Amp) for: “Motor Run”, “Damper Actuator”, “Auto Transfer”, “Drive Run”, “Hand Mode”, “Auto Mode”, “System Fault”, “Bypass Run” or “Serial Com Run”.
 - r. Damper control circuit with end of travel feedback capability. This circuit shall also include two adjustable wait time functions. One is a run delay time where the drive will operate at a preset speed before the damper opens to pressurize the system. The other time function is an interlock wait time, so if the damper has not fully opened within the specified time, a fault will be declared.
 - s. Line voltage sensors to monitor for brownout, blackout and single phase conditions. Fault levels for each condition must be adjustable to ensure the proper settings pursuant to each application.
 - t. Selectable energy savings and harmonic reduction mode. Drive automatically switches to Bypass (Across-the-line) when motor is running 60 Hz for a set time and automatically switches back when frequency reference changes.
2. Main input circuit breaker with a pad-lockable through-the-door handle mechanism, able to achieve a SCCR panel rating of 100kAIC.
3. Enclosure:
- a. NEMA / UL TYPE 12 Enclosure
 - b. NEMA / UL TYPE 3R enclosures for outdoor installations.
4. Additional options
- a. Line reactors shall be provided on the input side of the drive for harmonic suppression.
 - b. Output reactors shall be provided on the output side of the drive for motor protection in long motor lead length situations..
 - c. Output motor protection (dv/dt) filter shall be provided to accomplish, long motor lead length solutions.
 - d. PC software and cable for parameter upload/download/graphing shall be provided.

END OF SECTION **26** 29 23

This section of the *U of I Facilities Standards* establishes minimum requirements only.
It should not be used as a complete specification.