

## GUIDE SPECIFICATION

The following specification is intended as a guide only. The Engineer shall write the specifications to meet the project requirements in consultation with University of Cincinnati Construction Management (CM).

### ELECTRICAL – VARIABLE FREQUENCY DRIVES

#### PART 1 GENERAL

##### 1.01 DESCRIPTION

- A. Provide variable frequency drives (VFDs) as specified herein.
- B. Units shall operate variable torque loads.

##### 1.02 QUALITY ASSURANCE

- A. All equipment shall be Underwriters Laboratories (UL) listed and labeled and in accordance with applicable National Electrical Manufacturers Association (NEMA) and American National Standards Institute (ANSI) standards.
- B. Manufacturer must guarantee capability of existing motors to run with new VFDs with minimum system efficiency of 95 percent. If this requirement cannot be met, provide recommendations to UC CM (all recommendations are subject to final approval by UC CM).
- C. Manufacturer must recommend changes (e.g., filtering) necessary to preserve the quality of the electrical environment in which the drive must operate.
- D. Manufacturer must provide the following at no cost to the University:
  - 1. Start-up technician.
  - 2. One half-day of training.
  - 3. Factory-level technical/service manuals for units supplied.

##### 1.03 SUBMITTALS

- A. For review:
  - 1. Product data sheets.
  - 2. Wiring diagrams.
  - 3. Added equipment/modifications recommended to protect existing building electrical systems/equipment from harmonic current and voltage distortion.
- B. To be included in record and information manuals:
  - 1. One copy of each approved submittal.
  - 2. Complete installation and maintenance manuals.
  - 3. Test results.
  - 4. Certificate of System Completion.

**1.04 MANUFACTURERS**

- A. Variable frequency drives
  - 1. Square D Company.
  - 2. Siemens Automation.
  - 3. ABB.

**PART 2 PRODUCTS****2.01 VARIABLE FREQUENCY DRIVE UNIT**

- A. The adjustable frequency controllers (AFCs) shall comply with the applicable requirements of the latest standards of ANSI, Institute of Electrical and Electronics Engineers (IEEE), NEMA, and the National Electrical Code (NEC).
- B. Controllers and factory-mounted options shall be UL listed.
- C. The adjustable frequency controllers shall convert fixed utility voltage and frequency to variable voltage and frequency for AC motor speed control adjustable from 4 to 60 hertz.
- D. The AFCs shall produce adjustable voltage and frequency via a two-step process. The first section shall utilize a diode bridge rectifier converting AC to fixed-voltage DC.
- E. The rectifier shall maintain AC line side power factor at .95 or greater at any combination of speed or load. The second section shall utilize a pulse width modulated inverter that converts the DC potential into a variable frequency and voltage AC waveform suitable for speed control operation of any standard AC induction motor. This inverter section shall utilize insulated gate bipolar transistors (IGBTs).
- F. The adjustable frequency and voltage output shall provide constant volts-per-hertz excitation to the motor terminals up to 60 hertz. The full load output current of the AFC shall not be less than that listed for the motor equivalent horsepower as defined by NEC Table 430-150. Standard conditions of operation shall include:
  - 1. Incoming three-phase 480 volt, AC power,  $\pm 10$  percent, 50 or 60 hertz.
  - 2. AC line frequency variation  $\pm 2$  hertz.
  - 3. Service factor of 1.0 with 10 percent overload capability of 60 seconds.
  - 4. Humidity rating of 0 to 95 percent (noncondensing).
  - 5. Ambient temperature rating from 0 to 40 degrees C.
  - 6. Motor slip dependent speed regulation of 3 percent.
  - 7. Frequency stability of  $\pm 0.5$  percent for 24 hours with voltage regulation of  $\pm 2$  percent of maximum rated output voltage.
- G. Units to be supplied with fully protected, manual electric bypass to permit constant speed operation from AC line.

- H. The drive unit shall be mounted in a NEMA 12, 16-gauge-steel enclosure with a front accessibility requirement. Enclosure shall contain a disconnect switch and semiconductor-type current limiting fuses and circuit breaker, giving the unit a 65,000 amps interrupting capacity (AIC) rating. The disconnect switch shall extend through the enclosure front and shall be capable of being secured with a padlock.
- I. The enclosure shall contain separate fuses of the drive unit and the bypass circuit. There shall be an integrated contactor interlocked mechanically and electrically with a drive output contactor.
- J. Three-percent line reactors shall be provided at the AC line input to the drive to limit the maximum harmonic distortion and noise input to the drive.
- K. Motor thermal overloads shall be on the load side of the contactors.
- L. Safety terminals for high-static pressure, freeze-thermostat and smoke detector shutdown shall be common to both the drive and the bypass. Remote start/stop input terminals used to start the drive from the direct digital control (DDC) system shall also be common to both the drive and the bypass.
- M. The following factory integrally mounted options shall be provided with all adjustable frequency controllers:
  - 1. Manual electric bypass controls to allow operation of the motor directly from the AC power line. Bypass controls shall include a NEMA-rated adjustable frequency controller output contactor and AC line bypass starter, with overloads, mechanically and electrically interlocked for safety. In addition, a door-mounted Inverter-Off-Bypass selector switch and indicating lights for Inverter On, Bass On, and Standby shall be part of the bypass controls mounted within the AFC enclosure. An integral time delay while transferring from line to AFC shall be included.
  - 2. Door-mounted manual speed potentiometer.
  - 3. Door-mounted speed meter calibrated from 0 to 100 percent speed (or can be part of an LED or LCD display).
  - 4. Hand Off Automatic switch to allow operation of the drive if the DDC system is inoperative. The "Hand" position of the switch shall bypass the remote start/stop.

## 2.02 RATINGS

- A. Efficiency: 96 percent at 100 percent speed; 80 percent at 50 percent speed.
- B. Displacement power factor: .95.
- C. Input voltage: 480 volts  $\pm$ 15 percent.
- D. Input voltage frequency: 48 to 63 Hz.
- E. Over-torque capacity: 110 percent for 60 seconds.
- F. Output frequency range: 2.5 kilohertz to 15 kilohertz.
- G. Ambient temperature tolerance: 0 to 40 degrees C.
- H. Relative humidity tolerance: 0 to 95 percent at 40 degrees C.
- I. Maximum non-derated altitude: 100 meters.
- J. Speed range: 2.5 Hz to 72 Hz.

- K. Minimum power loss ride-through: 0.1 second.
- L. Adjustable ramp time range: 0.1 to 999 seconds.
- M. Speed regulation: 3 percent.
- N. Skip frequencies: 3 at 5 Hz bandwidth.
- O. Maximum corrected harmonic distortion reflected into supply: 5 percent..

### **2.03 CONTROL FUNCTIONS**

- A. All programmable parameters shall be adjustable from a digital operator keypad located on the front door of the VFD. In addition, all internal parameters shall also be accessible from the Siemens direct digital control system network for monitoring and control.
- B. Parameters shall include:
  - 1. Programmable frequency command (keyboard, remote).
  - 2. Programmable start command (keyboard, remote).
  - 3. Forward or reverse start, stop, and digital speed control via digital operator keypad.
  - 4. Programmable maximum and minimum frequency limits.
  - 5. Programmable acceleration and deceleration times.
  - 6. Programmable carrier frequencies, V/Hz, and critical frequency avoidance lockout zones.
  - 7. Programmable electronic overload and torque limits.
  - 8. Programmable multiple attempt restart.
  - 9. Programmable jog and preset speeds.
  - 10. Programmable dwell time at start to maximize motor starting torque.
  - 11. Programmable "Catch a Spinning Motor" function.
- C. The VFD shall have the following system interfaces:
  - 1. Inputs
    - a. Process interface from Siemens Apogee DDC system.
    - b. Remote mode start contact.
    - c. Remote preset speed contacts.
    - d. Remote reset contact.
  - 2. Outputs
    - a. Run relay with an isolated set of Form C contacts.
    - b. Two dry contact outputs to indicate protective function trip.
    - c. Analog output signal proportional to output frequency.
- D. Monitoring and displays:
  - 1. Direct network interface between drive and Siemens Apogee DDC controllers via protocol 1 floor level network (FLN) interface.

2. The VFD shall have an eight-character display indicating monitored functions as described in the following:
    - a. Output current.
    - b. Output frequency.
    - c. Motor RPM percent.
    - d. Trip cause.
  3. External pilot devices of functions:
    - a. Hand–Off–Auto switch.
    - b. Speed potentiometer.
    - c. Fault pilot light.
    - d. Drive on pilot light.
    - e. Bypass on pilot light.
- E. Protection functions. The VFD shall include the following protective features:
1. AC input line current limiting fuses rated at 200,000 AIC.
  2. DC over-voltage protection.
  3. Overcurrent protection.
  4. Over-voltage protection.
  5. Under-voltage protection.
  6. Overfrequency protection.
  7. Phase-loss protection.
  8. Overtemperature protection.
  9. Ground fault protection.
  10. Adjustable current limit.
  11. Line-to-line-to-ground short-circuit protection.
  12. AC line surge protection per IEEE 472-1974 surge withstand test.
  13. Overtemperature protection.

For any protective condition listed above, the controller will trip and an internal fault relay contact will close for remote trip indication. An auto-restart feature shall be provided for controller automatic restart (after phase loss, over-voltage and under-voltage trip condition only) at UC CM's option.

- F. Other functions:
1. The VFD unit will contain necessary relay option for interlocking, emergency shutdown, and so forth, and will have a minimum of two alarm relay outputs.
  2. Include network interface to the University of Cincinnati Siemens Apogee DDC system FLN.
  3. Provide 120 VAC three-wire control to allow AFD to interface with remote dry contacts at a distance of up to 500 feet.
  4. Provide automatic bypass to contactor if drive fails.

**PART 3 EXECUTION****3.01 APPLICATION**

- A. Provide VFDs sized for motor horsepower and voltage per NEMA and National Electric Code standards. Each drive shall be capable of operating continuously with the existing motor sizes found in this facility.

**3.02 STARTUP AND TESTING**

- A. Manufacturer's authorized field technical representative shall conduct startup and testing. The service shall include inspection, final adjustments, and installing parameters; final adjustments of ramps and frequency skip; operational checks; and a written report.
- B. Operate system for a minimum period of 7 consecutive days with no problems before submitting for final acceptance by UC CM.

**3.03 EQUIPMENT DEMONSTRATION AND TRAINING**

- A. After all system tests have been completed, schedule an instruction period with UC CM. Instruction is to be provided by the manufacturer's authorized field technician and shall last at least one half-day.
- B. Instruction is to include:
  - 1. Location of all components of the system.
  - 2. Demonstration of equipment.
  - 3. Maintenance, troubleshooting, and repair procedures.
  - 4. Programming procedures.
  - 5. Review of all technical documents and Operation and Maintenance Manuals.

**3.04 WARRANTY**

- A. The unit manufacturer is responsible for all defects, repairs, and replacements in materials and workmanship. Both shall be warranted for a period of 1 year.
- B. The manufacturer must have a local repair representative able to provide 24-hour turnaround on any failed unit.

**END**