

SECTION 26 29 23
VARIABLE FREQUENCY MOTOR CONTROLLERS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies 480 Vac rated adjustable frequency drive motor controller systems using insulated gate bipolar transistors (IGBT) for pulse width modulation technology (PWM).
2. The AFDs specified in this section shall be the product of a single vendor and mounted in the specified cabinet enclosure.
3. The terms AFD (adjustable frequency drive), ASD (adjustable speed drive), VFD (variable frequency drive), and VSD (variable speed drive) are interchangeable for the purposes of this specification.
4. Refer to the drawings for control and monitoring requirements including special interlocking requirements. Refer to the Control Section 40 61 96 for the control description for the AFD system.

B. System Requirements:

1. The AFD system shall convert 460 volt, 60-Hertz nominal input to a suitable voltage and frequency to cause a premium efficient, inverter duty, squirrel-cage induction motor to run at a speed proportional to an external input analog 4 to 20 ma dc or digital input command as specified for the required AFD speed range.
2. The AFD system shall include rectifier units, inverter units, control circuitry, protective equipment, input line reactors and output load reactors and other filters and accessories as necessary to provide the specified functions to meet voltage and current harmonics at the specified point of common connection and to mitigate the motor reflected voltage wave. Unless otherwise specified, the point of common connection for AFDs shall be the 480 distribution bus (motor control center, distribution panel, etc.) immediately upstream of the AFD.
3. The AFD system torque requirement shall match the pump torque requirement. Verify the pump type and select variable torque (VT) or constant torque (CT) as specified in the AFD Schedule. Select 6-Pulse units for small pump motors and 18-Pulse units for large pump motors.

C. AFD Schedule:

Equipment Name & Tag Number	Drive Number	Drive Horse Power	Drive Speed Range	Driven Equipment Specification	AFD Type	AFD Enclosure & Mounting	Distance (ft) from AFD to Driven Equipment Motor
50-FLC-326	50-VFD-326	5		EXISTING FLOCULATOR 3HP	VT 6P	NEMA-3R Gasketed, Wall Mount	20
50-FLC-327	50-VFD-327	5		EXISTING FLOCULATOR 3HP	VT 6P	NEMA-3R Gasketed, Wall Mount	20
50-FLC-328	50-VFD-328	5		EXISTING FLOCULATOR 3HP	VT 6P	NEMA-3R Gasketed, Wall Mount	20
50-FLC-329	50-VFD-329	5		EXISTING FLOCULATOR 3HP	VT 6P	NEMA-3R Gasketed, Wall Mount	20

D. Environmental Conditions:

1. Ambient conditions are specified in Section 01 11 80.

E. Seismic:

1. Freestanding AFDs shall be braced per Section 01 73 23.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEEE 519	IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power System
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 2	Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts
NEMA ICS 6	Industrial Control and Systems: Enclosures
NEMA ICS 7	Industrial Control and Systems: Adjustable-Speed Drives
NEMA ICS 7.1	Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems
NFPA 70	National Electrical Code (NEC)
UL Standard 508	Industrial Control Equipment

B. Industry Standards:

1. The AFD shall be UL 508 listed and shall conform to the requirements specified in NEMA ICS 2, 6, 7 and 7.1.

C. Unit Responsibility:

1. The Contractor shall assign unit responsibility for the adjustable frequency drives in this section as specified in Section 43 05 11-1.02 Unit Responsibility. The Contractor shall submit letters of certification with the shop drawings from the AFD manufacturer, the motor manufacturer, and the driven equipment manufacturer stating that they have reviewed each application and that the combination will satisfy the application duties required, for the actual motor sizes required, regardless of deviations from the scheduled "nominal horsepower."

1.03 PRODUCT HANDLING

- A. AFD units shall be shipped in air-cushion vans to ensure against shipping damage and packed in suitable protective containers. The units shall be inspected upon receipt for damage.

1.04 SUBMITTALS

- A. The following information shall be provided in accordance with Section 01 33 00:
1. Certificate of Unit Responsibility attesting that the Contractor has assigned, and that the manufacturer accepts, unit responsibility in accordance with the requirements of this Section and Section 43 05 11-1.02 Unit Responsibility. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
 2. Catalog and technical data including outline dimensions, shipping section dimensions, weight, and foundation requirements for all assemblies.
 3. Schematic diagrams and wiring connection diagram showing functions and identification of terminals.
 4. Voltage and current Total Harmonic Distortion (THD) calculations with line reactors or filter design to mitigate harmonics to meet IEEE-519, if applicable.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. AFDs shall be installed in the custom enclosures as specified and Candidate manufacturers include:
1. ABB ACQ-580
 2. Toshiba Series:
 - a. W7 18-Pulse for centrifugal fan and pump motors
 - b. G7 18-Pulse for slow speed and high-torque motors
 3. Cutler-Hammer SV9000
 4. General Electric AF-300
 5. Siemens Model 6SE32
 6. Square D Altivar Series
 7. Siemens-Robicon
 8. Allen Bradley
 9. Or equal

2.02 ENCLOSURES

- A. Provide AFD in NEMA enclosures with fan cooling and conformal coating protection on circuit boards for corrosive atmosphere protection.
1. General:
 - a. Provide enclosures with AFDs and custom control as required for the project and as indicated on the drawings. Each drive shall be designed for stand-alone operation and multiple drives shall not utilize shared components. Review the project site location, elevation, temperature, humidity, plant atmosphere, and load current-torque requirements to size the AFD and its associated enclosure with requirements specified herein and the control and monitoring devices and interlocks as indicated.
 - b. Enclosures shall be designed for indoor service. Each AFD system shall be mounted in a NEMA 250 internally force ventilated enclosure with UL approved Class 1 filters on ventilation openings. Enclosures shall be fabricated from 12-gage minimum thickness sheet steel with an interior frame or formed to provide a rigid structure.
 - c. Provide enclosure size to allow entry of power source and motor load cables as indicated on the drawings. Submit drawing of the source and load power cable location within the enclosure and indicated barriers from control and instrument wiring.
 - d. Door width shall not exceed 30 inches and shall be hung on removable-pin hinges, with three-point latch hardware, and handle latch for 3/8-inch-shackle padlock.
 2. Finish and Coatings:

- a. AFD systems enclosures shall be finished with corrosion protection coatings inside and outside for hydrogen sulfide atmospheres. The electrical and electronic assemblies shall have conformal coatings.

2.03 AFD ASSEMBLIES

A. General:

- 1. AFDs shall include the following assemblies:
 - a. Power disconnect using a thermal magnetic circuit breaker or fused disconnect sized for the specific application by the manufacturer.
 - b. A load reactor for dV/dT mitigation or motor terminator units for addressing dv/dt effects at the motor
 - c. Rectifier, direct current bus filter, and inverter.
 - d. Control circuitry interface with Operator Interface Unit
 - e. Output protection including phase overload

B. AFD Features:

- 1. Provided with the following features:
 - a. Fused control circuit transformer and microprocessor for system logic sequencing functions. Provide fuses with blown fuse indicator lamps.
 - b. Accept 4 to 20 mAdc speed reference signal.
 - c. A 4 to 20 mAdc output signal proportional to inverter output frequency for the speed range specified.
 - d. Adjustable minimum/maximum frequency limits:
 - 1) Minimum frequency shall be adjustable from 6 to 40 Hertz.
 - 2) Maximum frequency shall be adjustable from 48 to 90 Hertz.
 - e. Adjustable and independent timed linear acceleration and deceleration functions, adjustable from 6 to 20 seconds.
 - f. Current limiting.
 - g. Automatic restart.
 - h. Control Wiring:
 - 1) 600 volt stranded copper
 - 2) 90 degrees C color-coded insulation
 - 3) No. 16 AWG
 - i. Wiring Identification and Termination:
 - 1) Crimp type wire lugs with sleeve type markers at each termination point and numbered terminal blocks for external connections.
 - j. Electrically isolated discrete output contacts for ready, running, remote mode status and trouble alarm.
 - k. Conformal coated terminal blocks for control and signal wires entering and leaving the controller.
 - l. Control Power:
 - 1) Provide a 120 Vac, triple fused, control power transformer for cooling fans and external control circuits when required. Control circuits shall be isolated from power circuits by distance and by insulated barriers.

m. Provide 120 Vac or 24 Vdc as required for Operator Interface Unit.

C. Functional Requirements:

1. Supply Power:

- a. Operate continuously with supply power of 480 volts plus or minus 10 percent, 60 Hertz plus or minus 3 percent and remain on line and operate without damage to the AFD or connected load during a supply power under-voltage variation to the drive up to 85% of its nominal value for 30 milliseconds at full load.

2. Environmental Conditions:

a. Ambient temperature:

- 1) 0 to + 40 degrees C / [104 degrees F

3. Load:

- a. Capable of driving the specified maximum motor load continuously and under the following conditions:

- 1) Deliver 110 percent of the specified load for up to 60 seconds in variable torque applications.
- 2) Deliver 150 percent of the specified load for up to 60 seconds in constant torque applications.

4. Efficiency:

- a. Not less than 95 percent at 60 Hertz output driving the specified maximum load at rated torque and speed at 40 degrees C ambient based on measured input power versus output power with all specified components in the system.

5. Frequency and Voltage Regulation:

- a. Output frequency regulated to within 0.6 Hertz of the signal/output frequency relationship. Output voltage regulated to within 1.0 percent to produce minimum motor heating at any operating frequency within the specified range.

6. Frequency Range:

- a. AFD shall be capable of continuous operation with the specified load at any frequency between 6 and 60 Hertz unless noted otherwise.

7. Space and AFD Access:

- a. Enclosure size shall not exceed the size allotments specified on the drawings nor shall any portion of the AFD system exceed a height of 90 inches.
- b. Front accessible only and shall not require rear access.
- c. Mount against the wall without any clearance for ventilation or other purposes.
- d. Submit AFD in the enclosure drawing with the detail of front door and the internal arrangement, including the feeder and motor cables, and the control cables, and the instrument cable location and terminations.

8. Ambient Noise:

- a. Free field noise generated shall not exceed 85 dBA at 3 feet out from any point on the AFD enclosure under any normal operating condition.

9. Motor Coordination:

- a. AFDs shall be configured as required to maintain output voltage peaks at the connected motor windings from reaching levels damaging to the motor insulation. Provide protection integral to the AFD or as protective hardware to be installed at the motors.

- 1) Where motor terminator units are provided, they shall be rated for the environment in which they are located. Motor terminator units shall be:
 - a) Allen Bradley 1204 Motor Terminator for AFD with the maximum carrier frequency of 6 kilohertz,
 - b) Cutler Hammer Reflected Wave Trap (RWT) with the maximum carrier frequency of 12 kilohertz,
 - c) Or Equal product
- D. Protection and Annunciation:
1. Overcurrent Protection:
 - a. Electronic current limit at 150 percent of motor nameplate current and provide motor running overcurrent protection in compliance with NFPA 70.
 2. Short Circuit Protection:
 - a. Protected against load faults: bolted faults, phase to phase or phase to ground shall not damage the unit. Fault protection based on a power source short circuit capacity of 42,000 amperes RMS symmetrical at the AFD power input terminals with impedance or current limiting device provided.
 3. Line Voltage:
 - a. Protected against high and low line voltage on one or more phases.
 4. Internal Faults:
 - a. Internal fault monitoring system to detect malfunctions to protect from transient and sustained faults and to limit damage that may be caused.
 5. Motor Over Temperature:
 - a. Interface to motor over temperature device 2-ampere output contact to shut down and alarm if the motor becomes overheated.
 6. Fault Alarm:
 - a. Indicates the cause of any shutdown visible on the AFD keypad/display without opening the AFD enclosure. As a minimum, the following faults shall be alarmed:
 - 1) Motor over-temperature
 - 2) Motor overcurrent
 - 3) Incoming power line over/under/unbalanced-voltage
 - 4) AFD over-temperature
 - 5) AFD over-voltage
 - 6) AFD control failure
 7. Safety Features:
 - a. The AFD shall include:
 - 1) Padlock main disconnect handle in the "Off" position.
 - 2) Mechanical interlock to prevent opening enclosure door with disconnect in the "On" position while the unit door is open.
 - 3) Auxiliary contact on main disconnect to isolate 120Vac control power when fed from external source.
 - 4) Barriers and warning signs on terminals that are energized with the power disconnect "OFF".
 - 5) Separation and insulated barriers between the power and control and instrument products.

- 6) External emergency stop input
- 8. Reverse Direction Protection:
 - a. Provide protection from inadvertent operation in reverse where reverse rotation can damage the driven equipment.
- 9. Critical Speed Bypass:
 - a. Provide capability to program speed bypass for minimum two critical speed points.
- 10. Transient Voltage Protection:
 - a. Provide solid state transient voltage protection to meet or exceed ANSI C37.90.

2.04 CONTROL AND MONITORING DEVICES

- A. Front door mounted on the AFD enclosure between 36 inches and 72 inches above the floor for each unit:
 - 1. Digital Operator keypad/display.
 - 2. Local-Off-Remote door mounted selector switch.
 - 3. Manual speed control: OIU function
 - 4. Internal terminal strips for remote monitoring:
 - a. Run status
 - b. Trouble / Fail alarm
 - c. Auto Mode status
 - d. Additional devices as indicated on the drawings.
- B. Operator Interface Unit:
 - 1. Digital keypad/display for monitoring and controlling the drive and to input drive parameter settings with a backlit LCD or equally visible display with a minimum of 16 characters per line.
 - 2. Digital keypad for numerical settings in English engineering units and a guide to parameter settings. Setup operations and adjustments stored in non-volatile EEPROM memory transferable to new and spare boards. Settings shall be protected from unauthorized tampering, revision, or adjustment by a personal lockout code.
 - 3. The digital keypad to provide programming of the drive and include:
 - a. Up and Down Arrow Keys:
 - 1) Increase or decrease output frequency or data values.
 - b. Monitor Key:
 - 1) Selection of control mode.
 - c. Run and Stop Keys:
 - 1) Starting and stopping in the manual mode.
 - d. Fault Clear / Enter Keys:
 - 1) Reset fault conditions and enter chang
 - e. Program Key:
 - 1) Enter the program mode and adjust parameters.
 - f. Remote / Local Location Keys:
 - 1) Operation location and local speed control.

- g. Auto / Manual Mode Keys:
 - 1) Program mode.
 - h. Number Keys:
 - 1) 0 through 9 keys to access specific parameters.
 - i. Keypad Digital Illustrations:
 - 1) English and display the last 5 faults.
 - j. Frequency / Motor Speed Indication:
 - 1) Calibrated in Hertz and RPM.
 - k. Run Status Indication.
 - l. Ready Status Indication.
 - m. Fault Alarm Indication.
- C. Control and Monitoring Communication
- 1. None or:
 - a. Additional analog I/O as required for the project
 - b. Additional discrete I/O as required for the project

2.05 KEYPAD FUNCTIONS AND OPERATION

- A. Adjustment of the following parameters through the OIU digital keypad:
- 1. Current limit and torque boost.
 - 2. Maximum voltage level.
 - 3. Minimum/Maximum speed, Volts/Hertz, Upper and Lower limit.
 - 4. Adjustable acceleration rate and deceleration rate.
 - 5. Electronic thermal overload setting.
 - 6. Coast, controlled ramp or DC injection selectable modes of stopping.
 - 7. PID setpoint and time-function selection.
 - 8. Critical frequency avoidance:
 - a. Three set points selectable from 0 to maximum frequency with set points adjustable from 0-30 Hertz.

2.06 NAMEPLATES

- A. Nameplates shall be provided in accordance with the requirements of Section 26 05 00. Nameplates shall be provided for all drive enclosures. Provide equipment tag numbers and descriptions as shown [on the drawings] [in 1.01.C].

2.07 SPARE PARTS

- A. The following spare parts shall be supplied with each type or frame size AFD:
- 1. Three sets of all replaceable fuses.

2.08 PRODUCT DATA

- A. The following information shall be provided in accordance with Section 01 33 00:
- 1. Operation and maintenance information as specified in Section 01 78 23, including:

- a. Final reviewed submittal.
- b. As-built drive configuration settings.
2. Installation certification Section 43 05 11-Form A as specified in paragraph 3.01.
3. Training certification Section 43 05 11-Form B as specified in paragraph 3.03.

PART 3 EXECUTION

3.01 FIELD INSTALLATION

- A. Each adjustable speed controller shall be installed and tested by the Contractor with the assistance of factory-trained pump manufacturer engineer/technician and AFD engineer/technician in accordance with the manufacturer's specifications and Section 26 29 23, and witnessed by the Construction Manager.
- B. Manufacturers' factory representatives shall provide field testing for devices including the setup of the Operator Interface Unit and the setup of the data communication devices, where used. Upon satisfactory completion of the testing, the Contractor shall submit two certified copies of the test report to the Construction Manager.
- C. Component failure during testing will require repeating any test associated with the failure or modified components to demonstrate proper operation.
- D. The installation shall be certified on Form 43 05 11-A specified in Section 01 99 90.
 1. Adjust drive and perform "start-up" tests as recommended by manufacturer. Set parameters and carrier frequency for existing motors to avoid insulation damage.
 2. Establish proper direction of rotation for the motor controlled by the drive. Verify that the AFD is precluded from operating in a direction that can damage the driven equipment. Change motor or AFD power lead connection and not the AFD direction, where rotation is incorrect.
 3. Verify that the drive will operate properly both in the "manual speed control mode" and in the "remote or automatic mode" from a remote speed signal input.
 4. Set the maximum "locked rotor" current drawn during start-up recommended by the manufacturer and approved by the Construction Manager.
 5. Set the minimum and maximum speeds and the acceleration and deceleration "ramps" recommended by the Construction Manager.
 6. Verify the motor high temperature switch contacts are wired into the AFD 120 Vac control circuit and will trip on high winding temperature. Test or simulated the alarm and trip feature at the motor for high temperature and for high vibration, where used.
 7. Operate the drive at 100 percent speed for one hour and monitor output current. The output current shall remain below the full load current listed on the motor nameplate.
 8. Check for excessive heating of the drive and motor. Report any discrepancies to the Construction Manager.

3.02 HARMONIC TESTING

- A. The Testing Firm specified in Section 26 08 00 shall perform a harmonics acceptant test with all AFD motor controllers operating to verify compliance with IEEE-519 of less than 5 percent voltage THD and 12 percent current THD at the defined point of common

connection when running from Power Utility power source with a BMI-Dranetz or equal harmonic test set that provides a hard-copy record of the test results.

- B. The test shall also be run with power sourced from the standby generator where such a power source is being used at the project site. THD shall be limited to a maximum level of 8 percent voltage THD on standby generator operation.
- C. Submit the test performance to the Construction Manager per latest version NETA ATS Acceptance Testing Specifications. Refer to the electrical testing specification Section 26 08 00.

3.03 TRAINING

- A. Two hours of onsite AFD operation and maintenance training shall be provided for the Owner's Operation and Maintenance Staff.
- B. Manufacturers' factory representative shall conduct the training, upon acceptance of a resume submitted by the trainer.
- C. Training shall be certified on Form 43 05 11-B specified in Section 01 99 90.

END OF SECTION

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