SECTION 26 29 23
VARIABLE FREQUENCY DRIVES – 18 PULSE

PART 1 - GENERAL

1.1 SCOPE

A. This section covers ac voltage source, space vector pulse width modulated (PWM) type variable frequency drives for general or high performance constant or variable torque loads as shown on the project drawings or noted in project motor list.

B. Equipment provided under this section shall be fabricated, assembled, erected and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer, unless the engineer notes exceptions.

C. Governing Standards. Each variable frequency drive shall be designed, constructed and tested in accordance with the applicable standards of NEMA, ANSI, UL and IEEE and shall be designed for installation in accordance with the NEC. The drives shall be UL listed.

D. The VFD system shall fit in the space indicated on the drawings.

1.2 RELATED DOCUMENTS

A. Project motor list to contain application description, environmental descriptions for variable frequency drive and motor information (if available). Drawings for the project are provided if applicable.

1.3 SUBMITTALS

A. Submittals shall be custom prepared by the VFD manufacturer for this specific application. The shop drawing submittals shall include the following information for each size and type of drive being furnished:

B. Drawings
1. Name of manufacturer.
2. Types and model numbers.
3. Rated drive power.
4. Percent efficiency at 100 percent speed and 100 percent load.
5. Front and side views with overall dimensions and weights shown; and nameplate legends.
6. Schematics, including interlocks.
7. Wiring diagrams, including all internal and external devices and terminal blocks.
8. List of diagnostic indicators.
9. Stub-up locations
10. Shipping splits
11. Catalog cut sheets
12. List of spare drives and/or parts to be furnished.

C. Operation and Maintenance Data
1. Provide CD ROM to include, but not limited to, the following items. Printed manuals, if required, are to be specified in the motor project list.
   a. Operation & maintenance manual
   b. Start-up software
   c. Option descriptions and drawings

D. Test Reports (Provide with the Operation and Maintenance Data)
1. Drives supplier to provide typical factory test description. Drives are to be 100% tested at the factory prior to shipment. All drives are to be powered with a motor load.

1.4 RELATED STANDARDS

A. Codes: Provide equipment in full accordance with the latest applicable rules, regulations, and standards of:
   1. Local Laws and Ordinances.
   2. State and Federal Laws.
   3. National Electric Code (NEC).
   4. Underwriters Laboratories (UL).
   5. American National Standards Institute (ANSI).
   6. National Electrical Manufacturers Association (NEMA).
   7. Institute of Electrical and Electronics Engineers (IEEE).

B. The complete enclosed drive assembly shall be UL listed to UL508C.

1.5 QUALITY ASSURANCE

A. The VFD shall be designed and manufactured to a quality management system in according with ISO 9001. The VFD shall be supplied by a manufacturer who has considerable experience in the design and manufacturing of VFD of the ratings specified for a period of at least ten (10) years.

B. The entire VFD system, as described in Part 2, shall be factory assembled and system tested by the VFD manufacturer to assure a properly coordinated system.

1.6 DELIVERY, STORAGE AND HANDLING

A. The construction/installation manager is to protect the inverter against physical shocks and vibration during transport or storage. The equipment shall also be protected against water (rainfall) and excessive temperatures. Installation after a prolonged period of storage may require reform of the capacitors in the inverter. Consult manufacturer for details.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The variable frequency drive shall be manufactured by Siemens, or pre-approved equal. Approved manufacturers are as follows:
   1. SIEMENS
   2. ***[Pre-bid approved equal, meeting the detailed requirements of these specifications.]***
   3. ***[No substitutions are permitted.]***

2.2 GENERAL

A. Provide variable frequency controllers suitable for operating variable or constant torque loads. Controllers shall meet or exceed the ratings listed below:
   1. VFDs rated 50hp and higher shall consist of a input rectifier-grade phase-shifting transformer, Clean Power 18-pulse minimum converter section, output inverter and control logic section. All components listed shall be integral to the VFD lineup, factory wired and tested as a complete system. VFDs rated less than 50hp shall be 6-pulse converter types with minimum 3 % line reactors or DC choke.
   2. Input circuit breaker, interlocked with the enclosure door, with flange mounted handle to provide positive disconnect of incoming AC power. The handle and mechanism shall remain attached to the circuit breaker at all times, even when the enclosure door is open.
   3. The circuit breaker shall be rated in accordance with NEC and UL requirements.
   4. VFDs shall meet all requirements as outlined in the 1992 edition of IEEE 519 for each individual and total harmonic voltage and current distortion and as indicated in this specification. As per Table 10.2 of IEEE 519-1992, individual or simultaneous operation of the VFDs shall not add more than 3% total harmonic voltage distortion while operating at full load and speed from the utility source, or more than 5% while operating from standby generator (if applicable).

5. The VFD manufacturer shall not predict or be responsible for pre-existing voltage distortion on the line or distortion from sources supplied by others. Maximum input voltage unbalance shall be 0.5% as defined in NEMA MG 1 section 14.35.2.
6. As per Table 10.3 of IEEE 519-1992, maximum allowable total harmonic current demand distortion limits for each VFD operating at full load and speed shall not exceed 5% as calculated and measured at the point of common coupling (ISC/IL < 20).
7. The point of common coupling for all harmonic calculations and field measurements for both voltage and current distortion shall be defined as the plant designated PCC.
8. The short circuit current at point of common coupling under utility operation is ***[_____]*** amps. **[If short circuit current is unknown: The short circuit current used for harmonic calculations shall be defined as the total full load current with all VFDs operating multiplied by twenty. Example: (5) 100HP VFDs; Full load current = 5 x 126 amps = 630 amps. Short circuit current = 20 x 630 amps = 12,600 amps.]**
9. ***[Standby generator rating will be minimum [_____] kW with a minimum [_____] % subtransient reactance. A maximum of Qty. [_____] VFDs will operate simultaneously from the generator.]***
10. The use of harmonic filters to meet the harmonic requirements is not allowed.

B. Ratings
1. The drive system shall be at least 94% efficient at full load and full speed. Losses to be utilized in drive system efficiency calculation shall include input transformer, harmonic filter and power factor correction if applicable, VFD converter and output filter if applicable. Auxiliary controls, such as internal VFD control boards, cooling fans or pumps, shall be included in all loss calculations.
2. Rated Input Power: 460 - 480 Volts 60 Hz, +10%, -10% (at rated load), 3-phase.
3. Voltage Dip Ride-Through: VFD shall be capable of sustaining continued operation with a 10% dip in nominal line voltage and with a 15% dip for up to 1 minute. Output speed may decline only if current limit rating of VFD is exceeded.
4. Power Loss Ride-through: VFD shall have the capability of riding though power dips up to for 3 to 5 cycles without a controller trip depending on load and operating condition. In this extended ride through, the drive shall use the energy generated by the load inertia of the motor to power the electronic circuits.
5. Output Power ***[_____]*** HP, ***[_____]*** RPM, (460V) motor voltage 60 Hz.
6. Motor current ***[_____]*** Amps.
7. Ambient Temperature Range: 32 to 105°F (0 to 40°C).
8. Elevation: Up to 3,300 ft (1,000 meters) above MSL without derating.
9. Atmosphere: Non-condensing relative humidity to 95%.
10. AC Line Frequency Variation: 47 to 63 Hertz.
11. Power Unit Rating Basis: 110% rated current for one minute, at rated temperature for variable torque applications. 150% rated current for one minute, at rated temperature for constant torque applications.

C. Construction
1. The controller shall produce an adjustable AC voltage/frequency output. It shall have an output voltage regulator to maintain correct output V/Hz ratio despite incoming voltage variations.
2. The controller shall have a continuous output current rating of 100% of motor nameplate current.
3. The VFD is to be supplied with a transformer to provide phase shifting for a Clean Power 18 pulse or higher converter bridge. The phase shift transformers required shall be factory wired and mounted within the VFD enclosure as an integral part of the VFD assembly. Transformers external to the VFD enclosure are not acceptable.
4. The converter section shall be 18-pulse minimum utilizing diodes. The converter shall be a clean power controller which inherently provides sinusoidal current to the inverter section with minimal harmonics to flow back to the incoming power source.
5. 6-pulse converters may be used on drives rated less than 50hp.
6. The inverter output shall be generated by IGBTs. Pulse Width Modulation strategy will be of the space vector type implemented to generate a sine-coded output voltage. For

ratings above 200 HP, an advanced pulse edge modulation strategy shall be utilized to provide a VFD output voltage of at least 97% of input voltage.

7. The controller(s) shall be suitable for use with any standard NEMA design B squirrel-cage induction motor.
8. The drives shall be able to be located up to 165 ft. from motors with shielded cable for VFDs rated up to 200hp (656 ft. with an output reactor). For VFDs rated 250hp and above, motor cables may extend to 985 ft. when shielded cables are used. Longer distances may require the use of output reactors or filters.
9. The control logic section shall be fully digital and not require analog adjustment pots or fixed selector resistors. A power failure shall not necessitate a reload of any drive parameter or configuration.
10. All enclosure blowers shall be turned on only while the drive is running.

D. Basic Features

1. A door-mounted operator panel with integral LCD display shall be furnished, capable of controlling the VFD and setting drive parameters. The keypad shall include the following features:
    a. The digital display must present all diagnostic message and parameter values in English engineering units, without the use of codes.
    b. The digital keypad shall include at a minimum a manual start pushbutton, manual stop pushbutton, Hand/Auto pushbutton and additional control devices to scroll and enter numerical values.
    c. A plain English user menu, rather than codes, shall be provided in software in nonvolatile memory as a guide to parameter setting and resettable in the field through the keypad.
    d. The digital display may be selectively configured to display parameter names with set point and actual values selectable in percent or physical units, and up to three quasi-analog bar graphs of any parameter values. Parameter values to be displayed shall include
        1.) Speed in rpm.
        2.) Output current in amperes.
        3.) Output Frequency in hertz.
        4.) DC bus voltage.
        5.) Output voltage.
        6.) Total 3-phase output power in kW or HP.
        7.) Torque in Nm
        8.) Kilowatt-hour meter.
        9.) Elapsed time running meter.
2. The VFD shall include a customer selectable automatic restart feature. When enabled, the VFD shall automatically attempt to restart after a trip condition (programmable to allow for individual fault selection) resulting from for example supply failure, instantaneous overcurrent, overvoltage, or overload. For safety, the drive shall shut down and require manual reset and restart if the automatic reset/restart function (programmable for up to 10 attempts) is not successful within a customer programmable time period (programmable for up to 600s).
3. VFD shall have the capability of communicating via an RS-485 serial port or industrial Ethernet port.
    a. Serial communications shall be available for Profibus, Modbus RTU, or Modbus Plus protocols.
    b. Industrial Ethernet communications shall be available for Profinet, Ethernet IP or Modbus TCP/IP protocols.
    c. Data communication shall be preconfigured and not require special programming to access parameter values, status and fault data.
    d. VFD shall have a PID regulator for set point control.
    e. VFD shall have the following internal functions available for the implementation of control and interlocking functions:
        1.) Arithmetic (Adders, Subtractors, Multipliers, Dividers, and Comparators)

2.) Logic (AND, OR, XOR, NOT, Flip-Flop)
3.) Timers

E. Enclosure
1. All VFD components shall be factory mounted and wired on a dead front, grounded, NEMA 1 enclosure. If a free-standing enclosure is provided, then it shall be suitable for mounting on a concrete housekeeping pad.

F. Protective Features and Circuits
1. The controller shall include the following alarms and protective features:
a. Instantaneous overcurrent and overvoltage trip.
b. Undervoltage and power loss protection.
c. Power unit over temperature alarm and protection.
1.) Upon sensing an over temperature condition, the VFD is to be programmable to either limit its output to maintain the temperature below its limit, or to automatically trip.
d. Ground fault (when connected to a solidly grounded supply). A separate monitor shall be supplied, where noted on the drawing, for other types of high resistance or ungrounded systems.
e. An electronic overload circuit
1.) It shall be designed to protect an AC motor operated by the VFD output from extended overload operation on an inverse time basis.
2.) This electronic overload shall be UL and NEC recognized as adequate motor protection.
3.) No additional hardware such as motor overload relays or motor thermostats shall be required.
f. When power is restored after a complete power outage, the VFD shall be capable of catching the motor while it is still spinning and restoring it to proper operating speed without the use of an encoder.
g. The VFD shall be protected from damage due to the following:
1.) Three-phase short circuit on VFD output terminals.
2.) Loss of input power due to opening of VFD input disconnect device or utility power failure during VFD operation.
3.) Loss of one (1) phase of input power.
h. The VFD shall be able to withstand the following fault conditions without damage to the power circuit components:
1.) Failure to connect a motor to the VFD output.
2.) VFD output open circuit that may occur during operation.
3.) VFD output short circuit that may occur during operation.

G. Parameter Log
1. All drive setting adjustments and operation parameters shall be stored in a parameter log.
a. It lists allowable maximum and minimum points and the present set values.
b. It shall be accessible, depending on the communication option or requirement, via a RS-232, RS-485 serial or Ethernet port and on the keypad display.
c. The controller shall have a slot to allow the parameter log to be downloaded on to a compact flash memory card by using the keypad.

H. Input / Output Features
1. Two programmable analog inputs (0-20mA/0-10V), optionally isolated.
2. Two programmable analog outputs (0-20mA), optionally isolated.
3. Minimum six programmable digital inputs (24VDC).
4. Minimum three programmable digital outputs.
5. Temperature sensor input (PTC or KTY).

I. Diagnostic Features and Fault Handling
1. The VFD shall include a comprehensive microprocessor based digital diagnostic system which monitors its own control functions and displays faults and operating conditions.

2. A “Fault Log” shall be accessible via bus communications as well as line by line on the operator panel display. The "FAULT LOG" shall record, store, and display the following for the 64 most recent events:
   a. Time stamp
   b. Type of fault.
3. All faults and events shall be stored and with English descriptions in addition to fault codes.
4. Windows based software for start-up/commissioning, optimization, monitoring and diagnostics shall be provided for all drives. This software shall operate as a standalone PC application and be suitable for integration into higher level control engineering or automation systems. The software package shall support all types and ratings of drives supplied under this package.
5. First-time users shall be supported by dialog menus, with a standard graphics-based display maximizing clarity when setting the drive parameters. First commissioning is guided by wizards, which handle all the basic settings in the drive. This shall enable a drive to be up and running after only setting the preliminary parameters within the drive configuration process.
6. The software shall allow configuration including but not limited to the following:
   a. Digital and analog I/O terminals
   b. Bus interface
   c. Set point channel (e.g. fixed set points)
   d. Speed control (e.g. ramp-function generator, limits)
   e. Logic and mathematical functions
   f. Diagnostics
7. Experts shall be able to gain rapid access to the individual parameters via the expert list and not have to navigate dialogs.
8. In addition, the following functions shall be available for optimization purposes
   a. Motor identification
   b. Self-optimization
9. Modifications
   a. Any modifications to a standard product required to meet this specification shall be performed by the VFD manufacturer only. Distributor or system integrator changes to the VFD manufacturer's product are specifically disallowed.

J. ***[Drive Options]*** **Include as required or delete**

1. ***Provide the following options/modifications to the VFD. All options shall be factory mounted and wired within the VFD enclosure unless otherwise specified.***

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify that mounting surface is suitable for controller installation.

B. Do not install controller until building environment is maintained within the service conditions required by the manufacturer.

C. Inspect completed installation for physical damage, proper alignment, anchorage and grounding.

D. The manufacturer shall have the capability and personnel to assist in the start-up, training, service and maintenance of the equipment.

E. The contractor shall provide all labor, materials, equipment and incidentals required, and install, place in operation and field test the variable frequency drive(s).

F. VFD manufacturer shall provide the services of a factory technician for startup assistance and training.

3.2 ADJUSTMENTS AND CLEANING

A. Remove debris from drives and wipe dust and dirt from all components.

3.3 TESTING

A. Check tightness of all accessible mechanical and electrical connections to assure they are torqued to the minimum acceptable manufacture's recommendations.

B. Check all installed panels for proper grounding, fastening and alignment.

C. The VFD manufacturer shall have a quality system certified in accordance with ISO 9001-2000, and provide as a minimum the following quality assurance steps within his factory:

D. Incoming inspection of components and raw materials based on strategic supplier base and experience.

E. All drives subject to routine tests (megger, functional, no load operation and final inspection.

3.4 WARRANTY

A. Equipment manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment.

3.5 SPARE PARTS

A. The following spare parts shall be furnished:
   1. One control unit.
   2. One operator panel.
   3. Three of each type of fuse rated 460V or less.
   4. Three of each type of pilot lamp.

END OF SECTION