SECTION 15915

VARIABLE FREQUENCY DRIVES

PART 1 PART 1 - GENERAL

1.1 DESCRIPTION

A. This section provides specification requirements for adjustable speed, variable frequency drives or herein identified as VFDs for use with AC motors used at ANC.

B. The VFD manufacturer shall furnish, field test, adjust and certify all installed VFDs for satisfactory operation.

C. Any exceptions/deviations to this specification shall be submitted in writing with the Preliminary Design Submittal.

1.2 QUALITY ASSURANCE

A. The Basis of Design is equipment from Square D Company to set a standard for quality. Equivalent equipment from ABB will also be acceptable.

B. The manufacturer of the VFD shall be a certified ISO 9001 facility.

C. The VFD and all associated optional equipment shall be UL listed according to Power Conversion Equipment UL 508C. A UL label shall be attached inside each enclosure as verification.

D. The VFD shall be designed, constructed and tested in accordance with NEMA, NEC, VDE, IEC standards and CSA certified.

E. Every Power Converter shall be tested with an actual AC Induction Motor 100 percent loaded and temperature cycled within an environment chamber at 104 degrees F.

F. All drive door mounted pilot devices shall be tested to verify successful operation.

G. The VFD shall be submitted to a Hi-Pot test with all enclosed devices mounted and wired, prior to shipment.

H. Documentation shall be furnished to verify successful completion of the tests noted in 1.2.E, 1.2.F and 1.2.G above at the request of ANC.

1.3 REFERENCES AND STANDARDS

A. ANSI/NFPA 70 - National Electrical Code.

B. ANSI C84.1 - Voltages Tolerances for North America

C. CSA C22.2 No. 14-M91 - Industrial Control Equipment

D. IEC 68 Part 2-3 - Basic Environmental Testing Procedures Part 2: tests - Test Ca: Damp Heat

E. IEC 146.1 - Semiconductor Converters-General Requirements and Line Commutated Converters Part 1-1: Specifications of Basic Requirements

F. IEC 664 - Insulation Coordination for Equipment Within Low-Voltage Systems

G. IEC 447 - Man-Machine Interface Actuating Principles

H. IEC 439 Part 1 - Low Voltage Switchgear and Controlgear Assemblies

I. IEC 947 - Low Voltage Switchgear and Controlgear Components

J. IEC 364 - Electrical Installation of Buildings

K. IEC 204/NFPA 79 - Electrical Equipment of Industrial Machines/Industrial Machinery

L. IEC 106 - Guide for Specifying Environmental Conditions for Equipment Performance Rating

M. IEC 529 - Degrees of Protection Provided by Enclosure

N. IEC 1000 - Electromagnetic Compatibility

O. IEC 721 - Classification of Environmental Conditions

P. IEC 255-8 Overload Relays

Q. IEC 801-2,-3,-4,-5 - Immunity Tests

R. NEMA ICS 6 - Industrial Control and Systems Enclosures

S. NEMA ICS, Part 4 Overload Relays

T. NEMA 250 Enclosures for Electrical Equipment

U. NEMA ICS 2-321 - Electrical Interlocks

V. NEMA ICS7 - Industrial Control and Systems Adjustable Speed Drives

W. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection Installation and Operation of Adjustable Speed Drives

X. UL 50 - UL Standard for Safety Enclosures for Electrical Equipment

Y. UL 98 - UL Standard for Disconnect Switches

Z. UL 507 - UL Standard for Safety Electric Fans

AA. UL 508 - UL Standard for Safety Industrial Control Equipment

BB. UL 508C - UL Standard for Safety Power Conversion Equipment

CC. UL 991 - UL Standard for Safety Tests for Safety Related Controls employing Solid State Devices

DD. OSHA 1910.95 - AC Drive Controller Acoustical Noise

EE. Confirming to National Safe Transmit Association and International Safe Transmit Association Test for Packages Weighing 100 lbs or Over

1.4 SUBMITTALS

A. Provide the following information for all products as part of the Preliminary Design Submittal.

1. Elementary power and control wiring diagrams and enclosure outline drawings. The enclosure drawings shall include front and side views of the enclosures with overall dimensions and weights shown, conduit entrance locations and nameplate legends.

2. Standard catalog sheets showing voltage, horsepower, maximum current ratings and recommended replacement parts with part numbers shall be furnished for each different Horsepower rated VFD provided.

3. Submit Harmonic Analysis including sources of all assumptions. Provide harmonic analysis for operation on utility power and for operation on building standby generators if applicable (with either one or two generators operating).

4. Submit shop drawings showing specific VFD mounting arrangements. Include verification that mounting of VFD is suitable for Seismic Zone 4.

1.5 WARRANTY

A. Three year parts warranty shall be provided on materials and workmanship from date of final completion of project.

1.6 OWNERS MANUALS

A. Furnish two (2) complete sets of Operation and Maintenance Manuals and other information necessary for the operation and maintenance of the system.

PART 2 PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Square 'D'.

B. ABB.

2.2 GENERAL

A. Furnish complete variable-frequency drives (VFD) as specified herein for the fans, pumps and equipment required to be variable speed. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified.

B. MOTOR HEATING: Verify the thermal capability of all motors to be controlled via VFDs. Coordinate with the motor manufacturer to ensure that appropriate temperature detection or sensors are provided for motor protection. Verify that the motor service factor and design type are suitable for use with the VFD.

2.3 PRODUCT TYPE

A. The VFD shall be provided by Square D Company, Class 8839, Type ATV-66, or as approved. Substitutions shall include supporting documentation demonstrating that the alternative manufacturer meets all aspects of the specifications herein.

B. Alternate control techniques other than pulse width modulated (PWM) are not acceptable.

2.4 GENERAL DESCRIPTION

A. The VFD shall convert the input AC mains power to an adjustable frequency and voltage as defined in the following sections.

B. The input power section shall utilize a full wave bridge design incorporating diode rectifiers. The diode rectifiers shall convert fixed voltage and frequency, AC line power to fixed DC voltage. This power section shall be insensitive to phase rotation of the AC line.

C. The output power section shall change fixed DC voltage to adjustable frequency AC voltage. This section shall utilize insulated gate bipolar transistors (IGBTs), bipolar junction transistors (BJTs) or intelligent power modules (IPMs) as required by the current rating of the motor.

2.5 CONSTRUCTION

A. VFDs shall be mounted in a Type 12 enclosure with an external operated disconnect device.

B. A mechanical interlock shall prevent an operator from opening the VFD door when the disconnect is in the *on* position. Another mechanical interlock shall prevent an operator from placing the disconnect in the *on* position while the VFD door is open. It shall be possible for authorized personnel to defeat these interlocks.

C. Provisions shall be provided for locking all disconnects in the *off* position with up to three padlocks.

D. Provide current limiting fuses to protect the VFD input.

E. Provisions shall be made for accepting a padlock to lock the enclosure door.

2.6 MOTOR DATA

A. Refer to the drawings and specifications for listings of all motors requiring VFDs.

B. Motor sizes, voltages, RPM ratings, types, service factors, etc., shown in the documents shall be confirmed with the provider of the motor prior to ordering VFDs.

2.7 APPLICATION DATA

A. Each VFD shall be selected and sized to operate its respective load.

B. The speed range shall be from a minimum speed of 0.5 Hertz to a maximum speed of 250 Hz.

2.8 ENVIRONMENTAL RATINGS

A. The VFD shall be of construction that allows operation in a pollution Degree 3 environment. The VFD shall meet IEC 664-1 and NEMA ICS 1 Standards. VFDs that are only rated for Pollution Degree 2 environment shall not be allowed.

B. The VFD shall be designed to operate in an ambient temperature from 0 to + 40 degrees C (+32 to 104 degrees F).

C. The storage temperature range shall be minus 25 to plus 70 degrees C.

D. The maximum relative humidity shall be 95 percent at 40 degrees C, non-condensing.

E. The VFD shall be rated to operate at altitudes less than or equal to 3,300 feet (1000m). For altitudes above 3,300 feet, de-rate the VFD by 1.2 percent for every 300 feet (100m).

F. The VFD shall meet the IEC 68-2 Operational vibration specification.

2.9 RATINGS

A. The VFD shall be designed to operate from an input voltage of 200 plus or minus 15 percent Vac and 460 plus or minus 15 percent Vac.

B. The VFD shall operate from an input voltage frequency range from 47.5 to 63 Hertz.

C. The displacement power factor shall not be less than 0.95 lagging under any speed or load condition.

D. The efficiency of the VFD at 100 percent speed and load shall not be less than 96 percent.

E. The constant and variable torque rated VFD overcurrent capacity shall be 150 percent and 110 percent respectively for 1 minute.

F. The output carrier frequency of the VFD shall adjustable depending on VFD rating for low noise operation.

2.10 PROTECTION

A. Upon power-up the VFD shall automatically test for valid operation of memory, option module, loss of analog reference input, loss of communication, dynamic brake failure, DC to DC power supply, control power and the pre-charge circuit.

B. The VFD shall be UL 508C listed for use on distribution systems with 65,000A rms available fault current. The Power Converter shall meet short circuit withstandability of 65,000 rms symmetrical amperes as defined by NEMA ICS 7.1.09 and have the value listed on the VFD nameplate.

C. The Power Converter shall be protected against short circuits, between output phases and ground; and the logic and analog outputs.

D. The VFD shall have a minimum AC undervoltage power loss ride-through of 15 msec. The VFD shall have the user defined option of frequency fold-back to allow motor torque production to continue to increase the duration of the power loss ride-through.

E. The VFD shall have a selectable ride through function which shall allow the logic to maintain control for a minimum of one second without faulting.

F. For a fault condition other than a ground fault, short circuit or internal fault, an auto restart function shall provide up to 5 programmable restart attempts. The programmable time delay before restart attempts shall range from 1 second to 600 seconds.

G. The deceleration mode of the VFD shall be programmable for normal and fault conditions. The stop modes shall include free-wheel stop, fast stop and DC injection braking.

H. Upon loss of the analog process follower reference signal, the VFD shall fault and/or operate at a user defined speed set between software programmed low speed and high speed settings.

I. The VFD shall have solid state I^2t protection that is UL listed and meets UL 508 C as a Class 10 overload protection and meets IEC 947. The minimum adjustment range shall be from 0.45 to 1.05 percent of the current output of the VFD.

J. The VFD shall have a programmable fold-back function that shall anticipate a controller overload condition and fold back the frequency to avoid a fault condition.

K. There shall be 3 skip frequency ranges that can each be programmed with a selectable bandwidth of 2 or 5 Hz. The skip frequencies shall be programmed independently, back to back or overlapping.

L. The VFD shall include Metal Oxide Varistors (MOVs) wired to the incoming AC Mains.

2.11 ADJUSTMENTS AND CONFIGURATIONS

A. The VFD shall self-configure to the main operating supply voltage and frequency. No operator adjustments shall be required.

B. The VFD shall be factory pre-set to operate most common applications.

C. A choice of types of acceleration and deceleration ramps shall be available in the VFD software; linear and S curve.

D. The acceleration and deceleration ramp times shall be adjustable from 0.1 to 600 seconds.

E. The volts per frequency ratios shall be user selectable to meet variable torque loads, normal and high torque machine applications.

F. The memory shall retain and record run status and fault type of the past 8 faults.

G. Slip compensation shall be a software enabled function.

H. The VFD shall offer programmable DC injection braking that shall brake the AC motor by injecting DC current and creating a stationary magnetic pole in the stator. The level of current shall be adjustable between 50-150 percent of rated current and available from 0.0-30 seconds continuously.

2.12 OPERATOR INTERFACE

A. The operator interface terminal shall offer the modification of VFD adjustments via a touch keypad. All electrical values, configuration parameters, I/O assignments, application and activity function access, faults, local control, adjustment storage, self-test and diagnostics shall be in plain English.

B. The display shall be a high resolution, LCD back lighted screen.

C. The VFD model number, torque type, software revision number, horsepower, output current, motor frequency and motor voltage shall all be listed on the drive identification display as viewed on the LCD display.

D. The display shall be able to display speed reference, output frequency, output current, motor torque, output power, output voltage, line voltage, DC voltage, motor thermal state, drive thermal state, elapsed time, motor speed, machine speed reference and machine speed.

E. A single keystroke scrolling function shall allow dynamic switching between display variables.

F. The operator terminal shall offer a general menu consisting of parameter setting, I/O map, fault history, and drive configuration. A software lock shall limit access to the main menu. The main menu shall consist of keypad configuration, drive configuration, general configuration, diagnostic mode and drive initialization screens.

G. There shall be arrow keys that shall provide the ability to scroll through menus and screens, select or activate functions or increase the value of a selected parameter.

H. A data entry key shall allow the user to confirm a selected menu, numeric value or allow selection between multiple choices.

I. An escape key shall allow a parameter to return the existing value if adjustment is not required and the value is displayed. The escape function shall also return to a previous menu display.

J. A RUN key and a STOP key shall command a normal starting and stopping as programmed when the VFD is in keypad control mode. The STOP key must be active in all control modes.

K. A user interface shall be available that is a Windows NT based personal computer, Lonworks communication link or detachable operator interface.

L. The Keypad and all door mounted controls shall be similarly rated as the enclosure.

2.13 CONTROL

A. External pilot devices shall be able to be connected to a terminal strip for starting/stopping the VFD, speed control and displaying operating status. All control inputs and outputs shall be software assignable.

B. 2-wire or 3-wire control strategy shall be defined within the software. External relays or logic devices shall not be allowed.

C. VFD shall interface directly with the building control system via a Lonworks communications module provided with the VFD. Provide communications hardware/firmware within VFD to communicate directly with the controls system utilizing the networking communication protocol based on the Echelon Neuron 3150 microprocessor. VFD communication interface shall be Lonmark certified to the variable frequency drive profile. Where a profile has not been established, the profile shall be at a minimum proposed for adoption.

D. The following points shall, as a minimum, be available to the BAS through the Lonworks interface:

1. Inputs:

a. Analog speed input.

b. Start/stop.

c. Motor switching.

d. Fault reset.

2. Outputs:

a. Frequency.

b. Current.

c. Power.

d. Torque.

e. Voltage.

f. Thermal state.

g. Fault Status.

E. The VFD shall operate in standalone mode if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.

2.14 ISOLATION/BYPASS CONTACTORS

A. The VFD shall include IEC rated isolation and bypass contactors complete with thermal overload relay, molded case switch disconnect interlocked with the door, control circuit transformer, motor flux decay timer and AFC-OFF-BYPASS switch. The operator shall have full control of the bypass starter by operation of the door mounted selector switch.

2.15 HARMONIC ANALYSIS

A. A harmonic analysis shall be performed by the VFD manufacturer based upon system documentation consisting of but not limited to one-line diagrams and specific distribution

transformer and generator (where applicable) information consisting of KVA, %Z, X/R and subtransient reactance data. Vendor shall acquire all necessary input data and include documentation of sources in the submittal of the calculations. The data shall consist of but not be limited to total harmonic voltage distortion, K-factor and total rms current. If the resulting calculations determine that the harmonic distortion will be above the IEEE-519 specifications of 5 percent, additional isolation transformers or line reactors beyond those required below shall be supplied to lower the harmonic levels.

B. Provide minimum 3 percent impedance line reactors in stand-alone NEMA 1 enclosures for mounting separate from the VFD.

PART 3 PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate all details pertaining to the motor control equipment with the Division of these specifications where the controlled equipment is specified.

B. Coordinate with the building controls system to ensure complete compatibility of inputs and outputs prior to submitting submittals and shop drawings for approval.

C. Provide automatic reset of drives after the alarm condition has been cleared and a new “start” or “run” signal is received.

3.2 EXAMINATION

A. Tenant’s contractor shall verify that jobsite conditions for installation meet factory-recommended and code-required conditions for VFD installation prior to start-up. These shall included as a minimum:

1. Clearance spacing.

2. Temperature, contamination, dust, and moisture of the environment.

3. Conduit installation of the motor wiring and power wiring separation.

B. The VFD shall be covered and protected from construction dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

3.3 INSTALLATION

A. Verify that the location is ready to receive work and the dimensions are as indicated.

B. Do not install VFD until the building environment can be maintained within the service conditions required by the manufacturer. Before and during the installation, the VFD equipment shall be protected from site contaminants.

C. All details of the installation shall comply with the manufacturer’s applicable instructions.

D. Minimize the length of conductors between the drive and the motor to avoid motor damage from the reflected wave phenomenon.

E. Where the field conditions dictate long lengths of conductors between the VFD and motor, provide all measures necessary to protect motors from the reflected wave phenomenon. Measures may include coordination with the motor manufacturers to provide higher insulation voltage ratings, protection devices such as output reactors or special terminators, or BJT inverter output.

F. Mounting of VFD shall be suitable for Seismic Zone 4.

3.4 START-UP SERVICE

A. The manufacturer shall provide start-up commissioning of the variable-frequency drive and its optional circuits by a factory-certified service technician who is experienced in start-up and repair services. The commissioning personnel shall be the same personnel that will provide the factory service and warranty repairs at the customer's site. Sales personnel and other agents who are not factory-certified technicians for drive field repair shall not be acceptable as commissioning agents.

1. Start-up services shall include checking for proper operation and installation of the VFD, its options and its interface wiring to the building automation system. As a minimum, this service shall include:

a. Verification of Contractor wire terminations to the VFD and its optional circuitry.

b. One hour of Owner operator training on operation and service diagnostics at the time of the equipment commissioning.

c. Measurement for verification of proper operation on each of the following items:

1) Motor voltage and frequency. Verification of proper motor operation.

2) Control input for proper building automation system interface and control calibration.

3) Calibration check for the following set points (and adjustment as necessary): minimum speed, maximum speed, and acceleration and deceleration rates.

4) Total harmonic distortion and K-factor at the input to each VFD system under the full range of load conditions.

d. Submit results of all measurements. In addition, include a copy of all commissioning tests and measurements in the Maintenance Manuals.

3.5 CONTROL WIRING

A. Control wiring and control devices shall be provided under the specification section in which the controlled equipment is specified. Coordinate all related work.

B. Control wiring shall be routed completely separately from power wiring.

3.6 NAMEPLATES

A. Provide nameplates for all VFDs. Coordinate names with mechanical equipment lists.

END OF SECTION