SECTION 230925 - VARIABLE FREQUENCY DRIVE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-01 Specification sections, apply to work of this section.

1.2 WORK INCLUDED

A. Variable Frequency Drives: Provide and install Variable Torque Variable Frequency Drives (VFD) for variable speed where indicated on the plans, suitable for controlling NEMA Design B motors on continuous duty in variable volume applications. The VFD shall be listed by Underwriter's Laboratories, E.T.L., or CSA as approved by the Engineer and shall comply with the latest standards of ANSI, IEEE and the NEC.

B. General: The Variable Frequency Drive shall be capable of converting 460V + 10%-5%, three phase, 60 Hz + 2 Hz utility input power to variable frequency, three phase AC power for variable torque motor control continuously from 10% to 110% of base speed. Output shall have voltage to frequency relationship for a 460V, three phase motor. A transformer shall not be required for the input or output to operate on 460V. All general options and modifications shall mount within the VFD enclosure.

C. Basis of Design: Basis of this design is Graham Model 1576 for purposes of conveying the minimum acceptable level of performance and control interfaces. Variable Frequency Drives manufactured by ABB, Trane, or Yaskawa will be considered acceptable if all provisions of this specification can be met. Other manufacturers who can comply with all provisions of this specification shall be required to submit technical information brochures for pre-bid approval, in accordance with the provisions of Section 230100.

D. Submittals: Provide submittals in accordance with Paragraph titled "Power Factor" of this Section and with Section 230100. In addition, furnish the following technical information for Engineer's review and approval:

1. Complete technical information on the Variable Frequency Drive and all specified options, indicating all cabinet dimensions and space requirements for the VFD, including bypass contactors and line reactors.
2. Complete efficiency versus load and speed data for all VFD ratings showing that the VFD with necessary isolation transformers or line reactors is capable of providing full motor nameplate rated horsepower.

E. Power Factor: The power factor shall be maintained at 0.95 throughout the speed range of the drive.

1.3 RELATION TO OTHER WORK

A. Refer to the section, "General Mechanical Provisions" for related requirements. Refer to other sections of Division 23 and to all other applicable portions of the drawings and specifications.

B. This section directly relates in particular to sections (which may or may not be included in this division) which describe the following:

1. Direct Digital Control System and Expansion.
2. Performance Verification.
3. Air Handling Units.
4. Fans, Utility.
5. Electrical sections.

PART 2 - PRODUCTS

2.1 MATERIALS

A. The VFD unit shall be totally enclosed in a free-standing NEMA 1 enclosure for floor mounting, and shall be capable of dissipating any heat generated by the VFD circuitry. All unit-mounted controls shall be mounted on the face of the VFD enclosure. VFD shall be capable of operating in an ambient temperature of 0-40^{o}C.

B. The VFD shall incorporate an input molded case circuit breaker sized to provide a short circuit interrupting capacity of 30,000 symmetrical amps. The input breaker shall be mechanically interlocked with the power unit enclosure door.

2.2 UNIT REQUIREMENTS

A. Control Interface: The following control interfaces shall be provided at a terminal strip in the VFD as a minimum to assure control system integrity:

B. Speed Control Input: A 4-20mA signal proportional to speed shall be furnished under Section 230923 to the Fan System for directly controlling the speed of the VFD's when in automatic mode in response to static pressure.

C. Start/Stop Control: The VFD shall be capable of being started and stopped remotely by a maintained-contact start/stop relay furnished in this section and other remote relay contacts.

D. Control Interlock: The VFD shall provide an auxiliary control interlock output of 115 VAC whenever the VFD is enabled, to provide interlocking with the control system. The VFD shall be furnished with two sets of N.O. contacts for control interlocking. The VFD shall be provided with a 115 VAC control transformer so that no external 115 VAC power source is required.

E. Speed Signal Reference: The VFD shall furnish a 0-5 VDC or 4-20mA signal directly proportional to the output frequency of the VFD, for remote monitoring of the VFD speed at the building automation system under Section 230923.

F. Hand-Off-Auto Switch: The VFD shall be furnished with a door-mounted Hand-Off-Auto switch to allow switching of the speed control signal from the "Automatic" signal to a manually selected speed potentiometer on the VFD when in the "Hand" position. The VFD shall be disabled when in the "Off" position.

G. VFD Trip Contacts: The VFD shall be furnished with a set of N.O. contacts for remote annunciation to the building automation system under Section 230923.

H. Speed Potentiometer: A manually selected speed potentiometer shall be door-mounted to manually select the speed when the H-O-A switch is in "Hand" position.

I. Speed Meter: The VFD shall be furnished with a door-mounted speed meter (0-100%) to indicate the frequency of the VFD.

J. Manual Bypass with Magnetic Contactors: A door-mounted manual bypass switch shall be provided as a means of bypassing the VFD circuitry for emergency operation. In "normal" mode, the motor is controlled by the VFD. In "bypass" mode the motor is directly connected to the building power. Motor protection thermal overload shall be provided in "bypass" or "normal mode".

K. Manual bypass shall provide all the circuitry necessary to safely transfer the motor from the VFD to the power line, or from the line to the controller, while the motor is at zero speed. This option shall be located in the VFD cabinet. This enclosure section shall house all devices which must be energized at either 460 VAC or 115 VAC while operating in the bypass mode, for personnel safety.

1. Two motor contactors, electrically interlocked, shall be utilized. One contactor is to be between the VFD output and the motor, controlled by the VFD regulator; and the other one is to be between the bypass power line and the motor, providing across-the-line starting. Motor protection is to be provided in both the "normal" mode and the "bypass" mode by a motor overload relay. The 115 VAC relay control logic, allowing common start-stop commands in the "controller" mode and the "bypass" mode shall also be included within this enclosure.
2. The bypass section door shall include a "VFD-Off-Bypass" selector switch and "VFD Mode" indicator light and a "Bypass Mode" indicator light. Terminals shall be provided for remote light indication of mode selection.
3. The bypass option shall include a door interlocked, main power input disconnect circuit breaker, providing positive shutdown of all input power to both the bypass circuitry and the VFD.
4. The bypass circuit shall include a second door interlocked input disconnect circuit breaker installed in the VFD. This disconnect shall provide the ability to safely troubleshoot and test the controller, both energized and de-energized, while operating in the "bypass" mode.
5. Manual bypass with magnetic contactors shall be factory installed.

L. Variable Frequency Drive Controller: The VFD controller shall be completely solid state PWM or variable voltage source design. The VFD shall provide the following standard features:

1. Minimum and Maximum Speed Potentiometers shall be furnished to select a minimum (10-50%) and maximum (50-100%) output frequency.
2. Linear acceleration and deceleration functions adjustable from 4-20 seconds shall be furnished.
3. Safety features shall be provided to protect the VFD internal circuitry and motor, including but not limited to the following:

    a. Current limit feature to limit output current from 50-110% of that of the inverter rating. The current limit shall be designed to function automatically to prevent overcurrent trip due to momentary overload conditions, without shutdown.
    b. Instantaneous overcurrent trip to safely limit the output current in under 50 micro seconds due to phase to phase short circuits or severe overload conditions, without damage to input fuses or thyristors.
    c. Under- and over-voltage trip for non-momentary power or phase loss. Automatic restart shall occur on undervoltage condition.

d. Drive diagnostic fault indicator for continuous indication of drive status.
e. Isolated current and voltage signals from logic circuitry.
f. Fast-acting current limiting input fuses.
g. In the event of a sustained or momentary power loss, the control shall shut down safely without component failure. Upon return of power, the system shall automatically return to normal operation.
h. In the event of phase to phase short circuit on the output due to motor failure or power failure the control shall shut down safely without component failure.
i. Overtemperature safety shall be provided to shut down the VFD if the internal temperature becomes excessively high.
j. Solid-state ground-fault protection and indication shall be provided with the VFD.
k. VFD shall not require external 120 volt control circuit to perform any of the functions listed herein. Any control power required shall be provided internally from the VFD.
l. Motor Thermal Overload Protection shall be provided with door- mounted reset button and integral adjustments for the exact motor full load amps. Motor thermal overload relay shall be mounted inside the VFD cabinet.

M. Line Noise: The Variable Frequency Drive shall be furnished with Class H dry type isolation transformers, Class H insulation line reactors and other line noise filtering devices as required to prevent line noise from being transmitted into the AC power system. The line noise shall be no greater than 3% Harmonic Distortion and no more than a 16,400 volt-microsecond commutation notch area, in accordance with IEEE Standard 519-1981 for Special Applications. Line noise testing shall be accomplished at the jobsite with a spectrum analyzer to determine line noise levels. Line reactors or filters should be considered in sizing the VFD units to ensure that the overall power conversion efficiency does not reduce the fan capacity below that listed in the fan schedule.

N. Efficiency Rating: Complete efficiency versus load and speed data for all VFD ratings shall be submitted and shall be no less than 95% at 100% speed and 87% at 60% speed.

O. Factory Testing and Warranty: Each VFD shall be factory tested to insure reliability. Testing shall include component thermal cycling, logic system simulation tests and full load operation tests. The VFD shall be heat tested with power on for 50 hours at 50oC. VFD shall be furnished with manufacturer's written certification of tests conducted and shall be warranted for one full year (from date of startup) against component failure.

P. Diagnostic Features: The VFD shall contain diagnostics to allow on-site troubleshooting of fault conditions through built-in diagnostic indicators or through a diagnostic tester. One diagnostic tester must be included with the VFD package, to provide a functional test of each regulator card through a prewired diagnostic test port.

PART 3 - EXECUTION

3.1 GENERAL

A. Start-up Service: Provide the services of a factory-trained service technician during startup to ensure that the VFD units have been installed and wired correctly and that the factory-recommended startup procedures are followed for each of the VFD units installed.

B. Instructional Period: Provide one 8-hour instructional period to the Owner's maintenance personnel, scheduled at the Owner's convenience during the Warranty period, to provide instruction on the design, operation and maintenance of the Variable Frequency Drives.

END OF SECTION 230925