SECTION 230840 – VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes solid-state, PWM, VFDs for speed control of three-phase, squirrel-cage induction motors.

1.2 SUBMITTALS
   A. Product Data: For each model indicated, provide dimensions, weights, capacities at scheduled conditions, required clearances, electrical requirements, characteristics, wiring diagrams, components, and location and size of each field connection.
   B. Operation and maintenance data.
   C. Warranties: Special warranties specified in this Section.
   D. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
   E. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.3 QUALITY ASSURANCE
   A. Source Limitations: VFDs, field or factory-installed, shall be of a single type/model series through one source from a single manufacturer’s local factory authorized representative or distributor specializing in HVAC equipment and applications.
      1. The local HVAC representative or distributor shall provide all aspects of sales, start-up, service and warranty.
      2. The drive manufacturer shall have been engaged in the production of HVAC-specific VFD equipment for a minimum of ten years.
   B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100 by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFDs, minimum clearances between VFDs, and adjacent surfaces and other items. Comply with indicated dimensions and clearances as per drawings and manufacturer's recommendations.
   D. Comply with NFPA 70; NEMA ICS 7.0, AC Adjustable Speed Drives; NEMA MG-1 Part 31 Motors.
   E. The VFD shall be listed ISO 9001.
1.4 COORDINATION

A. Coordinate features of VFD's, installed units, accessories, devices with pilot devices and control circuits to which they connect.

B. Coordinate features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

C. The VFD FLA (Full Load Amp) rating shall meet or exceed the values in the NEC/UL Table for the scheduled motor.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace on-site VFD's or components of VFD's that fail in materials or workmanship for not less than two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer: ABB Model ACH580 ULH Drive with Eclipse Bypass.

2.2 VARIABLE FREQUENCY DRIVES

A. Description: NEMA ICS 2, VFD; listed and labeled as a complete unit and arranged to provide variable speed of a NEMA MG 1 Part 31, Design B, 3-phase, induction motor by adjusting output voltage and frequency. The VFD shall employ a 1600 volt full wave bridge rectifier, EMI / RFI filters, capacitors, and Insulated Gate Bipolar Transistors (IGBT's) as the output switching device, and AC transient protection system consisting of MOV's (phase to phase and phase to ground), a capacitor clamp, and 3 % impedance line reactors.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

C. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

D. Unit Operating Requirements:

1. **Input Voltage as indicated on Drawings; voltage tolerance for 208 V to 240 V, plus or minus 30 percent; voltage tolerance for 480 to 500 V, plus or minus 30 percent.**
2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
3. Capable of driving full load without derating at the following conditions:
   a) Drives Greater than 50 HP in NEMA 1 and NEMA 12 enclosures:
      1) Ambient Temperature -15 to 40 degrees C (5 to 104 degrees F): continuous with no current de-rate.
2) Ambient Temperature 40 degrees C (104 degrees F) to 50 degrees C (122 degrees F): VFD current de-rate will not be greater than 10%, not to exceed a rate of 1% current de-rate per 1 degrees C.

3) Oversizing: Intermittent operation is not permitted oversize unit as required for continuous operation.

   b) Drives 1 to 50 HP in NEMA 1 and 12 enclosures: Ambient Temperature: -15 to 50 degree C (5 to 122 degrees F) continuous.
   c) All drives in NEMA 3R Enclosures: Capable of operating with no current de-rate as per VFD manufacturer’s submittal data or VFD must be oversized.
   d) For VFDs installed in plenums: Enclosure shall be UL listed as a plenum rated VFD.
   e) Humidity: 5 to 95 percent (noncondensing).
   f) Altitude: 3300 feet.

4. Minimum Efficiency: 98 percent at 60 Hz, full load.


6. Overload Capability: 1.1 times the base load current for 60 seconds every 10 minutes; 1.3 times the base load current for 3 seconds every minute.

7. Starting Torque: 100 percent of rated torque, or as indicated on Drawings.

8. Speed Regulation: Plus or minus 1 percent.

9. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.

E. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 2 to a minimum of 22 seconds.
4. Deceleration: 2 to a minimum of 22 seconds.
5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

F. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors/coordinated AC transient protection system consisting of MOV’s (phase to phase and phase to ground), a capacitor clamp, and 3% impedance reactors.
2. Snubber networks to protect against malfunction due to system voltage transients.
3. EMI / RFI filters. The VFD assembly shall be CE marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level.
5. Input Current Harmonic distortion shall be < 10%.
6. Input Voltage Harmonic distortion shall be <5%.
7. Inverter over-temperature, overload, and overcurrent trips.
10. Critical Frequency Avoidance: Field-programmed notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination. Each critical frequency avoidance bands shall have an adjustable bandwidth up to 10Hz.
11. Instantaneous line-to-line and line-to-ground overcurrent trips.
15. Motor over-temperature fault.
16. Programmable loss-of-load (broken belt / coupling) indication. Indication shall be selectable as a control panel warning, relay output, or over network communications.
This function to include a programmable time delay to eliminate false loss-of-load indications.

G. Automatic Reset and Restart: To attempt three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

H. Motor Temperature Compensation at Slow Speeds: Adjustable current fallback based on output frequency for temperature protection of self-cooled fan-ventilated motors at slow speeds.

I. Status Lights: Door-mounted LED indicators and/or keypad shall indicate the following conditions:
   1. Power on.
   2. Run.
   3. Overvoltage.
   4. Line fault.
   5. Overcurrent.

   1. All VFD's shall have the same digital keypad, shall be removable, capable of remote mounting and uploading and downloading of parameter settings for start-up of multiple VFD's. The keypad shall include “Hand-Off-Auto” selections and manual speed control. The drive shall incorporate “bumpless transfer” of speed reference when switching between “Hand” and “Auto” modes.

K. Indicating Devices: Keypad, meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
   1. Output frequency (Hz).
   5. Motor torque (percent).
   6. Fault or alarming status (code).
   7. PID feedback signal (percent).
   8. DC-link voltage (VDC).
   9. Set-point frequency (Hz).
   10. Motor output voltage (V).

L. Control Signal Interface: Provide VFD with the following:
   1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 4-20 mA) and 6 programmable digital inputs.
   2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
      a. 0 to 10-V dc.
      b. 0-20 or 4-20 mA.
      c. Fixed frequencies using digital inputs.
      d. RS485.
e. Keypad display for local hand operation.

3. Output Signal Interface:
   a. A minimum of 2 analog output signal (4-20 mA), which can be programmed to any of the following:
      1) Output frequency (Hz).
      2) Output current (load).
      3) DC-link voltage (VDC).
      4) Motor torque (percent).
      5) Motor speed (rpm).
      6) Set-point frequency (Hz).

4. Remote Indication Interface: A minimum of three (3) programmable digital Form-C relay outputs standard, expandable to six (6). The relays shall include programmable on and off delay times, rated for maximum switching current 8 amps at 24 VDC or 250 VAC, open collector outputs are not acceptable for remote indication of the following:
   a. Motor running.
   b. Set-point speed reached.
   c. Fault and warning indication (over-temperature or overcurrent).
   d. PID high or low speed limits reached.

5. Run permissive circuit - There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command, the Drives shall provide a dry contact closure that will signal the damper to open. When the damper is fully open, an end-switch shall close, allowing the drive to run the motor. The drive shall also include a programmable start delay, for when an end-switch is not provided.

6. Start interlock circuit - Four separate start interlock (safety) inputs shall be provided. When any safety is opened, the motor shall be commanded to stop. The control panel will display the specific safety(s) that are open. The status of each safety shall be transmitted over the network communications. Wiring multiple safeties in series is not acceptable.

M. Communications: Provide an RS485 interface allowing VFD to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFD to be programmed via BMS control. Provide capability for VFD to retain these settings within the nonvolatile memory. Standard protocols shall be Modbus RTU, Johnson Controls MS/TP bus, and Siemens Building Technologies FLN. The Protocol shall be resident in each VFD, “certified” by the governing authority. VFD manufacturer shall supply one gateway, hardware device, etc. per VFD, multiple VFD’s sharing one gateway, hardware device, etc. is not permitted.

The embedded BACnet connection shall be a MS/TP interface. The drive shall be BTL Listed to Revision 14 or later. Use of non-BTL Listed drives are not acceptable. The drive shall be classified as an Applications Specific Controller (B-ASC).

1. The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC including, but not limited to:
   a. Data Sharing: Read Property Multiple-B, Write Property Multiple-B, COV-B
   b. Device Management: Time Synchronization-B
   c. Object Type Support: MSV, Loop

N. Manual/Automatic Bypass: Magnetic contactor system consisting of a VFD output contactor, bypass contactor, and VFD-only isolating switch and/or fuses arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Provide
with door interlocked circuit breaker to disconnect all input power from the drive and all internally mounted bypass options. Include controller-off-bypass keypad and/or selector switch for selecting operating mode and indicator lights for indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load). The bypass controller shall be a NEMA ICS 2, full-voltage, non-reversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either bypass or drive operating motor mode. The DDC system shall also be able to monitor and start stop if the motor is running in the VFD mode or bypass mode. The bypass shall provide single-phase motor protection and undervoltage protection of bypass assembly, bypass contactor coils, etc.

O. Integral Disconnecting Means: NEMA AB 1, molded-case switch or KS 1, nonfusible switch with lockable handle.

P. The drive shall include an isolated USB port and software application for interface between the drive and a laptop. A non-isolated USB port is not acceptable.

Q. Advanced power metering abilities shall be included in the drive:
   1. Instantaneous output power (kW)
   2. Total power, broken down by kWh, MWh, and GWh units of measurement. Power meters that only display kWh and roll over or “max out” once the maximum kWh value is reached, are not acceptable. There shall be resettable and non-resettable total power meters within the drive.
   3. Time based kWh metering for: current hour, previous hour, current day, and previous day.
   4. Energy saving calculation shall be included that shows the energy and dollars saved by the drive.

2.3 ENCLOSURES

A. NEMA 1 indoors as detailed herein and/or shown on drawings.

B. The drive shall have cooling fans that are designed for field replacement. The primary cooling fan shall operate only when required and be variable speed for increased longevity and lower noise levels. Drives whose primary cooling fans are not variable speed, shall include a spare cooling fan.

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated and comply with UL 508.

B. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

C. Standard Displays on Keypad:
   1. Output frequency (Hz).
   2. Set-point frequency (Hz).
4. DC-link voltage (VDC).
5. Motor torque (percent).
7. Motor output voltage (V).

D. Historical Logging Information and Displays:
   1. Real-time clock with current time and date built-into the VFD. The clock shall have a battery backup. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays, four (4) separate, independent timer functions that have both weekday and weekend settings.
   2. Running log of total power versus time.
   3. Total run time.
   4. Fault log, maintaining last 16 faults with time and date stamp for each.

2.5 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested VFDs before shipping.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, drive, and load.

B. Select rating of controllers to suit motor controlled based on horsepower and FLA (Full Load Amp).

3.2 INSTALLATION

A. Mount VFD where indicated on Drawings in accordance with the manufacturer's recommendations.

3.3 IDENTIFICATION

A. Identify VFDs, components, and control wiring according to Division 23 Section "Identification for HVAC Piping and Equipment."

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices according to Division 26 and manufacturers approved methods.

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where available.
1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each VFD element, bus, component connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Testing: Perform the following field quality-control testing:
   1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Manufacturer's Field Service: Engage the local, factory-authorized service representative to inspect field-assembled components and equipment installation, including pretesting and adjusting VFDs and start-up. The Flying Restart and Ride-Through Related Functions shall be adjusted in accordance with EPRI Guidelines. A certified start-up form shall be completed for each drive with a copy provided to the owner and a copy kept on file at the manufacturer.

D. Test Reports: Prepare a written report to record the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.6 TRAINING

A. Provide four (4) hours of on-site training to the Owner's designated personnel. Training shall include installation, programming, maintenance, and operation of the VFD(s) and bypasses.

3.7 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

END OF SECTION 230840