

## DIVISION 15 - MECHANICAL

### Section 15870 – Variable Frequency Drives

#### Introduction

This specification is to cover a complete variable frequency motor drive (VFD) consisting of a pulse width modulated (PWM) inverter output waveform (VVI, six-step, and current source drives are not acceptable) designed for use on a standard NEMA Design B induction motor. The VFD shall employ a 1600 volt full wave bridge rectifier, 5% impedance AC or DC Line Reactor, EMI/ RFI filters, capacitors, and Insulated Gate Bipolar Transistors (IGBT's) as the output switching device.

The drive manufacturer shall have a representative exclusively for HVAC products, both sales and service will be the same organization for sole source responsibility.

#### Part 1 - General

- Quality Assurance
  - Referenced Standards
    - Institute of Electrical and Electronic Engineers (IEEE) Standard 519-1992, IEEE Guide for Harmonic Content and Control.
    - Underwriter Laboratories: UL508C
    - National Electrical Manufacturer's Association (NEMA) ICS 7.0, AC Adjustable Speed Drives.
    - IEC 16800 Parts 1 and 2.
  - Qualifications
    - VFD's and options shall be UL listed as a complete assembly. VFD's that require the customer to supply external fuses for the VFD to UL listed are not acceptable. The base VFD shall be UL listed for 100 KAIC without the need for input fuses.
    - CE Mark- European Union Electro Magnetic Compatibility directive, a requirement for CE marking. The VFD shall meet product standard EN 61800-3 for the First Environment restricted level.
    - Acceptable Manufactures- ABB ACH Series, 550.
    - Substitutions must have written approval by the Design professional 2 weeks prior to date of bid. Written approval does not relieve supplier of specification requirements. All exceptions to this specification shall be submitted in writing to the Consulting Engineer at that time.
    - All VFD's shall be provided by the authorized local Rep/Distributor and be of one manufacturer. All HVAC OEM'S (AHU, Pumps, Cooling towers, etc.) shall allow VFD's to be shipped to factory for mounting or HVAC OEM units are to be deigned to interface/accommodate field mounting of VFD's.
    - All VFD's that are manufactured by a third party and "brand labeled" shall not be acceptable.
- Submittals
  - Submittals shall include the following information:
    - Outline dimensions, conduit entry locations and weight, customer connection and power wiring diagrams, technical product description include a complete list of options provided.
    - Compliance to IEEE 519- harmonic analysis for particular jobsite including total harmonic distortion (BOTH VOLTAGE and TDD). Using job specific electrical information the VFD manufacturer shall provide calculations showing total harmonic voltage distortion, is less than 5% at point of common coupling. Input line filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE standard 519. All VFD's shall include a minimum of 5 % impedance reactors, **no exceptions**.

## Part 2 – Products

- Variable Frequency Drive
  - The VFD shall be listed ISO9001 and the package as specified herein shall be enclosed in a UL listed Type 1, 12 (indoor enclosures) or 3R (outdoor enclosure) as applicable/specified.
  - The VFD tolerated voltage window shall allow the VFD to operate from a line of +30% nominal, and -35% nominal voltage as a minimum.
    - Environmental operating conditions: -15 to 40°C to (5 to 104°F) ambient temperature continuous with no current de-rate. From 40°C (104°F) to 50°C (122°F) ambient temperature range, VFD current de-rate will not be greater than 10% and not exceed a rate of 1% current de-rate per 1°C or VFD must be oversized. VFD's that can operate at 40°C intermittently (during a 24 hour period) are not acceptable and must be oversized. Altitude 0 to 3300 feet above sea level, less than 95% humidity, non-condensing. Enclosure shall be UL listed as a plenum rated VFD. VFD's without these ratings are not acceptable.
  - All VFD's shall have the following standard features:
    - 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.
    - There shall be a built-in time clock in the VFD keypad. The clock shall have a battery back up with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. 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.
    - The VFD's shall utilize pre-programmed HVAC application macro's specifically designed to facilitate start-up.
    - The VFD shall have cooling fans designed for replacement without requiring removing the VFD from the wall or removal of circuit boards.
    - The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).
    - The VFD shall automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal.
    - The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL table 430-150 for 4-pole motors.
    - The VFD shall have integral 5% impedance line reactors to reduce the harmonics to the power line and to add protection from AC line transients. The 5% impedance may be from dual (positive and negative DC bus) reactors, or 5% impedance AC line reactors. VFD's with only one 5% DC reactor shall add AC line reactors.
    - The VFD shall include a coordinated AC transient protection system consisting of 4-120 joule rated MOV's (phase to phase and phase to ground), a capacitor clamp, and 5% impedance reactors.
    - The VFD shall be capable of sensing a loss of load (broken belt/broken coupling) and signal a warning or fault as required.
    - If there is a loss of the input reference the VFD shall give the user the option of either(1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user.
  - All VFD's shall have the following adjustments:
    - Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed.
    - Two (2) PID setpoint controllers shall be standard in the drive, using the microprocessor for the closed loop control. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop

powering a transmitter supplied by others. The PID setpoint shall be adjustable from the VFD keypad, analog inputs, or over the communications bus. The PID parameter values may be changed with a digital input, serial communications or from the keypad. There shall be an independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain setpoint of an independent process (i.e. valves, dampers, cooling tower bypass valve control, chilled water valve control, etc.) and be accessible from the serial communication network. The setpoints shall be available in engineering units.

- Two (2) programmable analog inputs shall accept current or voltage signals.
  - Two (2) programmable analog outputs. (0-20ma or 4-20ma)
  - Six (6) programmable digital inputs allowing multiple safeties, run permissive circuits for damper and valve control, etc.
  - The VFD shall include a “run permissive circuit” that will provide a normally open contact whenever a run command is provided (local or remote start command in VFD or bypass mode). The VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). The VFD system (VFD or bypass) shall not operate the motor until it receives a dry contact closure from a damper or valve end-switch. When the VFD system safety interlock (fire detector, freezestat, high static pressure switch, etc) opens, the motor shall coast to a stop and the run permissive contact shall open, closing the damper or valve.
  - Three (3) programmable digital Form-C relay outputs standard, expandable to (6). The relays shall include programmable on and off delay times and adjustable hysteresis. The relays shall be rated for maximum switching current 8 amps at 24 VDC or 250 VAC. Maximum voltage 30 VDC and 250 VAC with maximum continuous current rating 2 amps RMS. Outputs shall be true from C type contacts; open collector outputs are not acceptable.
  - Seven (7) programmable preset speeds.
  - The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.
  - The VFD shall reduce the carrier frequency on actual VFD temperature that allows highest carrier frequency without derating the VFD.
  - The VFD shall include password protection against parameter changes.
- The Keypad shall include a backlit LCD display be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable).
  - All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three selectable values will be displayed in real time, in complete English words.
  - The VFD shall include a fireman’s override input. Upon receipt of a contact closure from the fireman’s control station, the VFD shall override all other inputs (analog/digital, serial communication, and all keypad commands) and force the motor to run at the adjustable, preset speed.
  - Serial Communications
    - The VFD shall have an RS-485 port as standard. The standard protocols shall be Modbus RTU, Johnson Controls N2 bus, Siemens Building Technologies FLN and BACnet available. No additional hardware, firmware, gateways, etc. shall be required for these standard protocols. Optional protocols for Lon Works, Profibus, Ethernet, and DeviceNet shall be available, and have the protocol in each VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be “certified” by the governing authority, non-certified protocols are not allowed. If additional gateway, hardware, etc. is required to obtain the BACnet, Modbus, etc. interfaces, the VFD manufacturer shall supply one gateway, hardware device, etc. per VFD. Multiple VFD’s sharing one gateway, hardware, etc. shall not be acceptable.
    - The BACnet connection shall be an RS485, MSTP interface operating at 9.6, 19.2, 38.4 or 76.8Kbps. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). The interface shall support all BIBBS (BACnet Interoperability Building Blocks) defined by the BACnet standard profile for a B-ASC.
    - The drive shall have the capability of allowing the DDC (Direct Digital Control/ Building Automation

System) to monitor feedback, such as process variable feedback, output speed/ frequency, etc. monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information, remote VFD fault reset keypad “Hand” or “Auto” selected, bypass selected, the ability to change the PID setpoint, and the ability to force the unit to bypass(if bypass is specified) shall be transmitted over the serial communications bus. The DDC system shall also be able to monitor and start stop if the motor is running in the VFD mode or bypass mode. (if bypass mode is specified)

- The VFD shall allow the DDC to control the drive’s digital and analog, inputs and outputs. For example, the analog outputs may be used to modulating chilled water valves or cooling tower bypass valves, digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation.
- EMI/RFI filters. All VFD’s shall include EMI/RFI filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level.
- Bypass – All features shall be UL listed by the drive manufacturer as a complete assembly and carry a UL508 label.
  - An output contactor, bypass, contactor and VFD only disconnect/service switch and/or fuses. Overload protection and shall be provided in both drive and bypass modes.
  - Door inter-locked, pad-lockable circuit breaker that will disconnect all input power from the drive and all internally mounted options.
  - Fused VFD only disconnect (service switch) and/or fast acting fuses exclusive to the VFD to allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection, maintaining bypass capability. Bypass designs that incorporate fuses common to both the VFD and the bypass will not be accepted. Three contactor by pass schemes are not acceptable, as a VFD input contactor is not a NEC recognized, lockable, physical disconnect and is an unacceptable means of safely disconnecting power to VFD.
  - The drive/ bypass shall provide single-phase motor protection and under-voltage protection in both the VFD and bypass modes.
  - The following operators shall be provided: a. Bypass Hand-Off Auto; b. Drive mode selector; c. Bypass mode selector; d. Bypass fault reset.
  - The following indicating lights (LED type/ pilot light) shall be provided. A test mode or push to test feature shall be provided: a. Power-on (Ready); b. Run enable (safeties) open; c. Drive mode select damper opening; d. Bypass mode selected; e. Drive running; f. Bypass running; g. Drive fault; h. Bypass fault; i. Bypass H-O-A mode; j. Automatic transfer to bypass selected; k. Safety open; l. Damper open; m. Damper end-switch made.
  - The following relay (form C) outputs from the bypass shall be provided: a. System started; b. System running; c. Bypass override enabled; d. Drive fault; e. Bypass fault motor overload or underload (broken belt); f. Bypass H-O-A position.
  - Customer Interlock Terminal Strip for connection of freeze, fire, smoke contacts, and external start command. The remote start/stop contact shall operate in VFD and bypass modes.
  - Dedicated digital input that will transfer motor from VFD mode to bypass mode upon dry contact closure for fireman’s override. Two modes of operation are required.
    - One mode forces the motor to bypass operation.
    - The second fireman’s override mode remains as above but will also defeat all safeties and inputs (run until destruction).
  - Class 20 or 30 (selectable) electronic motor overload protection shall be included.
  - Provide capability to select manual or automatic bypass.

### Part 3- Execution

- Installation
  - Installation shall be the responsibility of the mechanical contractor as outlined in the installation manual.
  - Power wiring shall be completed by the electrical contractor as outlined in the installation manual.

- Start-Up
  - Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and copy kept on file at the manufacturer.
  
- Product Support
  - Factory trained application engineering and service personnel shall be locally available at both the specifying and installation locations. A 24/365 (24 hour/ 365 days per year) technical support line shall be available on a toll- free line.
  - A computer based training CD and 4 hour on-site training shall include installation, programming, and operation of the VFD, bypass and serial communication.
  
- Warranty
  - Warranty shall be 24 months from the date of substantial completion. The warranty shall include all parts, labor, travel time and expenses. There shall be 24/365 support available via a toll free phone number.

**End of Section 15870**