

LOW VOLTAGE VARIABLE FREQUENCY DRIVE SPECIFICATION

Model H2 Series

Abstract

- This specification defines the requirements for Low Voltage Variable Frequency Drives for the operation of Low Voltage motors.
- The format of this specification is based on the CSI (Construction Specification Institute) standard 26 29 23.

Three Part Spec
Part 1 General
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Part 3 Execution

SECTION 26 29 23
VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.01 SCOPE

- A. This specification describes the electrical, environmental and agency requirements for three-phase, Variable Frequency Drives (VFD) as specified herein and as shown on the contract drawings.

1.02 RELATED SECTIONS

1.03 REFERENCES

- A. The variable frequency drives and all components shall be designed, manufactured and tested in accordance with the latest applicable standards.
1. NFPA 70 – National Electric Code (NEC)
 2. UL 50 – UL Standard for Safety for Enclosures for Electrical Equipment
 3. UL 61800-5-1 – UL Standard for Safety, Variable Speed Drive Systems
 4. UL 61800-3 - EMC immunity requirements
 5. UL 508A – UL Standard for Safety for Industrial Control Panels
 6. UL 508C – UL Power Conversion Equipment
 7. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
 8. NEMA – Application Guide For AC Variable Speed Drive Systems
 9. NEMA ICS 7.1 – Safety Standards for Construction and Guide for Selection, Installation and Operation of Variable Speed Drive Systems
 10. VFD's shall be UL / cUL listed.
 11. VFD's shall carry the CE mark.
 12. IEEE-519-2014 – Harmonic Control in Electrical Systems
- B. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

1.04 SUBMITTALS - FOR REVIEW/APPROVAL

- A. The following information shall be submitted to the Engineer.
1. Dimensioned outline drawing
 2. Schematic diagram
 3. Power and control connection diagram(s)
- B. Submit one (1) .pdf copy of the above information.

1.05 SUBMITTALS - FOR INFORMATION

- A. When requested by the Engineer the following product information shall be submitted:
1. Descriptive bulletins
 2. Product Instruction manual
 3. Spare Parts List
 4. Harmonic Analysis (if applicable to IEEE-519 systems)

1.06 SUBMITTALS - FOR CLOSEOUT

- A. The following information shall be submitted for record purposes prior to final payment.
1. Final as-built drawings and information for items listed section in 1.04 and 1.05.

1.07 QUALIFICATIONS

- A. For the equipment specified herein, the manufacturer shall be ISO 9001 certified.
- B. The supplier of this equipment shall have produced similar electrical equipment for a minimum period of ten (10) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- C. Variable Frequency Drives shall be on the basis of Benshaw H2 Series for function and quality.
- D. The VFD's shall have a design life of 10 years with proper maintenance.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.09 INSTRUCTION MANUALS

- A. One (1) copy of the equipment instruction manual shall be provided with each item.
- B. Instruction manuals shall include the following information:
1. Installation Guidelines
 2. LCD Operation (Viewing, Programming and Fault monitoring)
 3. Parameter settings and descriptions
 4. Trouble shooting
 5. Maintenance
 6. Equipment Ratings (Technical Specifications)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Benschaw
- B. _____
- C. _____

Naming specific vendors does not imply acceptance of their standard products nor relieve them from meeting these specifications in their entirety.

2.02 VARIABLE FREQUENCY DRIVES (VFD)

- A. Where shown on the drawings, variable frequency drives with the below ratings shall have the following features:

Voltage	HP Range
240	7.5 ~ 125
480	7.5 ~ 800
575	7.5 ~ 125

1. The VFD shall be rated for 480 VAC source voltage (optional input voltages of 208, 240, 380 and 575 VAC). The VFD shall provide microprocessor-based control for three-phase induction motors. The controller's full load output current rating shall meet or exceed NEC Table 430-150 and be based on an ambient temperature of 40° C (Normal Duty) or 50° C (Heavy Duty).
2. The VFD shall be of the Pulse Width Modulated (PWM) design converting the utility input voltage and frequency to a variable voltage and frequency output via a two-step operation. Variable Current Source VFD's are not acceptable. Insulated Gate Bipolar Transistors (IGBT's) shall be used in the inverter section. Bipolar Junction Transistors, GTO's or SCR's are not acceptable.
3. The VFD shall have an adjustable switching frequency.
4. The VFD shall have efficiency at full load and speed \geq 95%.
5. The VFD shall maintain the line side displacement power factor at no less than 0.96, regardless of speed and load.
6. The VFD shall have a one (1) minute overload current rating of 110%/120% for normal duty drives. The VFD shall have a one (1) minute overload current rating of 150% for heavy duty drives. The drives shall have a six (6) second overload current rating of 140%.
7. The VFD shall be capable of operating any NEMA design B squirrel cage induction motor, regardless of manufacturer, with a horsepower and current rating within the capacity of the VFD.
8. The VFD shall have an integral EMI/RFI filter as standard.
9. Insensitive to input line rotation.
10. The VFD's shall have the listed environmental "degree of protection" ratings.

240V	7.5 ~ 125 HP	UL Open (IP20), UL Type 1 achieved with optional conduit box
480V	7.5 ~ 300 HP	UL Open (IP20), UL Type 1 achieved with optional conduit box
	400 ~ 800 HP	UL Open (IP00), UL Type 1 achieved with optional conduit box
575V	7.5 ~ 30 HP	UL Type 1 (includes conduit box)
	40 ~ 125 HP	UL Open (IP20), UL Type 1 achieved with optional conduit box

B. Standard operating conditions shall be:

1. Incoming Power: Three-phase, [208 – 240] [380 – 500][525 – 600] Vac (-15% to +10%) and 50/60 Hz (+/-5 Hz) power to a fixed potential DC bus level.
2. Frequency accuracy - +/-1% of maximum output frequency.
3. Ambient Temperature (Normal Duty): 14°F~104°F (- 10°C~40°C). A 2.5% / °C current derating required up to 122°F (50°C) max.
4. Humidity: 0 to 95% (non-condensing and non-corrosive).
5. Altitude: 0 to 3,300 feet (1000 meters) above sea level.
6. Storage Temperature: -4°F~149°F (-20°C - 65°C).

C. HMI (LCD Display/Keypad)

1. Frequently accessed VFD programmable parameters shall be accessible from an LCD Display/Keypad located on the front of the VFD. The LCD shall have a 3-line alphanumeric programmable display with status indicators. Keypads must use plain English words for parameters, status, and diagnostic messages. Keypads that are difficult to read or understand are not acceptable, and particularly those that use alphanumeric code and tables. The LCD shall have a contrast adjustment and be easily visible in normal ambient light.
2. The keypad shall include a HAND and AUTO pushbutton selection. Both start/stop source and speed reference shall be independently programmable for Keypad, Remote I/O, or Field Bus.
3. The keypad shall have Read, Write and Save capability.
4. The keypad shall have password protection.
5. Upon initial power up of the VFD, the keypad shall display a Quick Start guide that will sequence the minimum necessary parameter adjustments for general start up.
6. The operator interface shall consist of an LCD display/keypad located on the front of the VFD. Features shall include:
 - a. Pushbuttons for selection, display, and modification of the VFD characteristics as follows:
 - 1) Scroll left, Scroll right, Scroll up/increase, Scroll down/decrease
 - 2) Mode Button
 - 3) Program/Enter
 - 4) Escape
 - 5) Reset
 - 6) Hand / Local Start
 - 7) Stop / Off
 - 8) Auto / Remote Start
 - 9) Multi-function Button (programmable function)



- b. The keypad LCD shall provide 3-lines of data and have a backlit alphanumeric LCD display.
- c. The operator shall be able to scroll through the keypad menu to choose between the following screens:
 - 1) Monitor Mode
 - 2) Parameter Mode
 - 3) Trip (Fault) Mode
 - 4) Configure Mode
 - 5) User/Macro Mode

D. Control Functions

- a. The following functions, at a minimum, are to be available:
 - 1) Control Method - V/Hz. Control, Sensorless Vector Control, Slip Compensation
 - 2) V/Hz. Pattern – Linear, Squared, User Defined
 - 3) Torque Boost
 - 4) Start/Stop command from keypad, remote or communications port
 - 5) Speed reference from keypad, remote or communications port
 - 6) Jog and Jog/Start
 - 7) Fire Mode start and run
 - 8) Motor direction selection
 - 9) Minimum and Maximum speed limits
 - 10) Acceleration and deceleration times
 - 11) Critical (skip) frequency avoidance
 - 12) Current limit
 - 13) Multiple attempt reset and restart function
 - 14) Multiple-step speed inputs
 - 15) Catch a spinning motor (Flying start)
 - 16) DC brake current magnitude and time
 - 17) PID process controller
 - 18) KEB (Kinetic Energy Buffering) Load inertia dependent ride-through during utility loss.



2. The VFD shall have the following interfaces:
 - a. Inputs – A minimum of seven (7) programmable digital inputs, two (2) analog inputs (one 4-20mA, one 0-10VDC) and serial communications interface shall be provided with the following available as a minimum:
 - 1) Remote Hand/Auto
 - 2) Remote Start/Stop
 - 3) Remote Forward/Reverse
 - 4) Remote preset speeds
 - 5) Remote external trip
 - 6) Remote fault reset
 - 7) Emergency Stop – Quick Stop
 - 8) Drive Enable/Disable
 - 9) Process control speed reference interface, 4-20mA DC
 - 10) Potentiometer with 0-10VDC speed reference interface
 - 11) RS-485 (Modbus-RTU) interface terminals
- E. Outputs – A minimum of five (5) discrete programmable relay outputs, one (1) programmable open collector output, and two (2) programmable analog outputs shall be provided, with the following available at minimum.
 1. Programmable relay outputs and open collector output selectable with the following available at minimum:
 - a. Fault
 - b. Run
 - c. Stop
 - d. Ready
 - e. Jogging
 - f. At speed
 - g. In Hand, In Auto
 - h. Over-temperature
 2. Programmable analog output signals selectable with the following available at minimum:
 - a. Motor current
 - b. Output frequency
 - c. Motor voltage
 - d. DC Bus voltage
 - e. Target frequency
 - f. Output power
 - g. PID reference and feedback



3. Monitoring and Displays
 - a. The VFD display shall be an LCD type capable of displaying three (3) lines of text and the following status indicators:
 - 1) Stop
 - 2) Forward
 - 3) Reverse
 - 4) Warning/Alarm
 - 5) Fault
 - 6) Input/Output (I/O) terminal status
 - 7) Hand (LED)
 - 8) Auto (LED)
 - 9) Fault/Reset (LED)
4. The VFD keypad shall be capable of displaying the following monitoring functions at a minimum:
 - a. Output frequency
 - b. Frequency reference
 - c. Motor speed
 - d. Motor current
 - e. Motor power
 - f. Motor voltage
 - g. DC-bus voltage
 - h. VFD internal temperature
 - i. Voltage level of analog input
 - j. Current level of analog input
 - k. Digital inputs status
 - l. Digital (relay) outputs status
5. Protective Functions
 - a. The VFD shall include the following protective features at minimum:
 - 1) Motor Overload
 - 2) Over-current
 - 3) Over-voltage
 - 4) Under-voltage
 - 5) Input/Output phase loss
 - 6) Over-temperature
 - 7) Motor stalled



- 8) Motor over-temperature (PTC Input req'd)
 - 9) Motor under-load
 - 10) Inverter Fault
 - 11) Loss of Signal
 - b. The VFD shall provide ground fault protection. VFD's with no ground fault protection during running are not acceptable.
- F. Communications
1. The VFD shall include as standard communications protocols.
 - a. Modbus-RTU
 - b. N2 Metasys
 - c. BACnet
 2. The VFD shall have optional communications capabilities (option card)
 - a. Ethernet IP / Modbus TCP
 - b. Lonworks
 3. Diagnostic Features
 - a. Fault History
 - 1) Record and log faults
 - 2) Indicate the most recent first, and store the last five (5) faults
- G. PC Interface
1. Programming and trouble-shooting functions shall be available by using a personal computer's USB port and Windows™ based software. The software shall permit control and monitoring via the USB port. The manufacturer shall supply a diskette (or link to download) the required software. An easily understood instruction manual and software help screens shall also be provided. The computer software shall be used for modifying the drive setup and reviewing diagnostic and trend information. Provide one copy of the advanced programming software.



H. Enclosed VFD – Packaged drive

1. Enclosure - The VFD enclosure shall be NEMA [1] [12] [3R]. The VFD shall have complete front accessibility with easily removable assemblies.
 - a. Thermal magnetic breaker or HMCP to provide a disconnect means. The operating handle shall protrude through the door. The disconnect shall not be mounted on the door. The handle position shall indicate ON, OFF, and TRIPPED condition. The handle shall have provisions for padlocking in the OFF position with at least three (3) padlocks. Interlocks shall prevent unauthorized opening or closing of the VFD door with the disconnect handle in the ON position. Door handle interlock can be defeated by qualified maintenance personnel.
 - b. Optional - AC input line current limiting fuses shall provide a means of disconnecting the VFD from the line under fault conditions.
 - c. Optional - Three contactor bypass shall include a VFD input isolation contactor, bypass contactor and a VFD output contactor that is electrically and mechanically interlocked with the bypass contactor. The bypass control circuit shall include control logic, VFD-Off-Bypass switch, bypass status light and motor overload relay.
 - d. Space heater(s) with thermostat for Nema 3R enclosures to minimize condensation potential upon drive shutdown.
 - e. Laminated plastic or steel nameplate engraved with user's identifying name or number.
 - f. 120 VAC control power to allow VFD to interface with control relays (dry contacts).

I. IEEE-519 Drives (Optional)

1. The system containing the VFD shall comply with the levels of total harmonic distortion for line voltage and line current as defined in IEEE 519-2014 by utilizing harmonic filters (passive or 18-pulse) integrally mounted in the VFD enclosure.
2. A harmonic analysis shall be done using data of the utility transformer feeding the installation (kVA capacity, X/R ratio and impedance) as noted on the customer supplied drawings and the total system load. The analysis shall show harmonics at the primary of the transformer as well as at the VFD input. Harmonic Analysis shall be done utilizing PC based software programs
3. The contractor shall provide any needed information to the VFD supplier three (3) weeks prior to requiring harmonic analysis.

J. Spare Parts

1. The Main PC Boards shall be supplied as spares, one for each different VFD supplied above 50 HP. These include one each of the following.
 - a. LCD (display/keypad)
 - b. Input (Filter) PCB
 - c. Control PCB
 - d. I/O CPU PCB
 - e. I/O TB PCB
 - f. Fan SMPS

K. Service and Support

1. The VFD manufacturer shall maintain, as part of a national network, engineering service facilities within 100 miles of project to provide start-up service, emergency service calls, repair work, service contracts, maintenance and training of customer personnel.

PART 3 EXECUTION

3.01 EXAMINATION

3.02 FACTORY TESTING

- A. Factory acceptance test (FAT) or factory test in short shall follow the drive manufacturer's standard test procedures unless otherwise specified.
- B. The factory test shall take place at the same facility where the drive is being manufactured.
- C. The factory test shall help ensure proper operation of the drive including but not limited to electrical circuitry, mechanical assembly, software, control and monitoring.
- D. The factory test shall, at minimum, include following:
 1. Visual inspection / check to verify physical dimensions and degree of protection for enclosures, mechanical assembly of components, hardware torquing marks and marking of cables, wires and terminals
 2. Point-to-point electrical resistance (ohm) check or voltage check (using a digital voltmeter) to verify all the electrical connections
 3. Verification of programming (factory settings) of parameters. The following standard factory tests shall be performed on the equipment provided under this section.
 4. Verification of proper operation of all fans.
 5. Functional tests to verify proper functionality of the drive
- E. When specified, the testing shall include an optional loaded run that operates the drive on a dynamometer.
- F. The test results shall be submitted to the customer as part of O&M manuals.
- G. When specified, a customer witness test shall be provided by the manufacturer.
 1. The witness test shall take place at the facility where the drive is manufactured.
 2. Witness test shall test and demonstrate the functionality and operation of the drive as well as the operator interface.
 3. A projected test schedule and a copy of proposed test procedures shall be provided by the manufacturer in advance of the test date.
- H. The manufacturer shall provide one (1) copy of the factory test report.

3.03 INSTALLATION

- A. The Contractor under the technical direction of the manufacturer's service representative shall perform installation.



3.04 FIELD QUALITY CONTROL

- A. Provide the services of a qualified manufacturer's employed Field Service Engineer to assist the Contractor in installation and start-up of the equipment specified under this section. Field Service personnel shall be factory trained with periodic updates and have experience with the same model of VFD on the job site. Sales representatives will not be acceptable to perform this work. The manufacturer's service representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, installation as specified in manufacturer's installation instructions, wiring, application dependent adjustments, and verification of proper VFD operation.
- B. The Contractor under the technical direction of the manufacturer's service representative shall perform the following minimum work.
 - 1. Inspection and final adjustments.
 - 2. Operational and functional checks of the VFD.
 - 3. The contractor shall certify that he has read the drive manufacturer's installation instructions and has installed the VFD in accordance with those instructions.
- C. The Contractor shall provide one (1) copy of the manufacturer's field start-up report before final payment is made.

3.05 WARRANTY

- A. Warranty to commence 24 months from the date of shipment. Warranty Service to include all parts and time on-site. Travel and Expenses (T&E) invoiced separately.

3.06 FIELD TESTING

- A. Optional field testing (519 VFD's)
 - 1. The contractor shall perform harmonic measurements at the point where the utility feeds multiple customers (PCC) to verify compliance with IEEE519-2014. A report of the voltage THD and current TDD shall be sent to the engineer. The contractor shall provide labor, material, and protection as needed to access the test points. The readings shall be taken with all drives and all other loads at full load, or as close as field conditions allow.
 - 2. Optionally harmonics can be measured at the input to the enclosed VFD to show that the addition of this drive does not significantly increase harmonic distortion.

3.07 TRAINING

- A. The Contractor shall provide a training session for up to ____ owner's representatives for ____ normal workdays with a maximum of ____ trips at a job site location determined by the owner. Training and instruction time shall be in addition to that required for start-up service.
- B. The manufacturer's qualified representative shall conduct the training.
- C. The training program shall consist of the following:
 - 1. Instructions on the proper operation of the equipment.
 - 2. Instructions on the proper maintenance of the equipment.