AQUAVAR® INTELLIGENT PUMP CONTROLLER

Typical Engineering Specifications

PART 1- GENERAL

1.0 DESCRIPTION

1.0.1 This specification covers complete variable frequency drives (VFDs) designated on the drawing schedules to be variable speed. All standard and optional features shall be included within the VFD panel.

1.0.2 The VFD shall be IP20, IP00, NEMA 1, NEMA 1, NEMA 3R, or NEMA 4X as required on the schedule. The VFD shall have been evaluated by UL and found acceptable for mounting in a plenum or other air handling compartment. Manufacturer shall supply a copy of the UL plenum evaluation upon request.

1.0.3 The VFD shall be tested to UL 508C. The appropriate UL label shall be applied. When the VFDs are to be located in Canada, C-UL certifications shall apply. VFD shall be manufactured in ISO 9001, 2000 certified facilities.

1.0.4 The VFD shall be CE marked and conform to the European Union Electromagnetic Compatibility directive.

1.0.5 The VFD shall be UL listed for a short circuit current rating of 100 kA and labeled with this rating.

1.0.6 The VFD manufacturer shall supply the VFD and all necessary controls as herein specified.

PART 2 – PRODUCTS

2.0 COMPONENTS

2.0.1 The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for the driven load and to eliminate the need for motor de-rating.

2.0.2 When properly sized, the VFD shall allow the motor to produce full rated power at rated motor voltage, current, and speed without using the motor's service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

2.0.3 The VFD shall include an input full-wave bridge rectifier and maintain a fundamental (displacement) power factor near unity regardless of speed or load.

2.0.4 The VFD shall have a dual 5% impedance DC link reactor on the positive and negative rails of the DC bus to minimize power line harmonics and protect the VFD from power line transients. The chokes shall be non-saturating. Swinging chokes that do not provide full harmonic filtering throughout the entire load range are not acceptable. VFDs with saturating (non-linear) DC link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load, where harmonic performance is most critical.

2.0.5 The VFD's full load output current rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 120% of rated torque for up to 0.5 second while starting.

2.0.6 A programmable automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continuously monitor the motor's speed and load to adjust the applied voltage to maximize energy savings.

2.0.7 Output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD.

2.0.8 An automatic motor adaptation algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to perform the test.

2.0.9 Galvanic isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete digital I/O shall include additional isolation modules.

2.0.10 VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD operation while reducing motor noise. VFDs with fixed carrier frequency are not acceptable.

2.1 PROTECTIVE FEATURES

2.1.1 A minimum of Class 20 I^2t electronic motor overload protection for single motor applications shall be provided. Overload protection shall automatically compensate for changes in motor speed.

2.1.2 Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain language. Codes are not acceptable.

2.1.3 Protect VFD from input phase loss. The VFD should be able to protect itself from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost.

2.1.4 Protect from under voltage. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output, without faulting, with an input voltage as low as 70% of the nominal voltage.

2.1.5 Protect from over voltage. The VFD shall continue to operate without faulting with a momentary input voltage as high as 130% of the nominal voltage.

2.1.6 The VFD shall incorporate a programmable motor preheat feature to keep the motor warm and prevent condensation build up in the motor when it is stopped in a damp environment by providing the motor stator with a controlled level of current.

2.1.7 VFD shall include a "signal loss detection" algorithm with adjustable time delay to sense the loss of an analog input signal. It shall also include a programmable time delay to eliminate nuisance signal loss indications. The functions after detection shall be programmable.

2.1.8 VFD shall function normally when the keypad is removed while the VFD is running. No warnings or alarms shall be issued as a result of removing the keypad.

2.1.9 VFD shall catch a rotating motor operating forward or reverse up to full speed without VFD fault or component damage.

2.1.10 Selectable over-voltage control shall be provided to protect the drive from power regenerated by the motor while maintaining control of the driven load.

2.1.11 VFD shall include current sensors on all three output phases to accurately measure motor current, protect the VFD from output short circuits, output ground faults, and act as a motor overload. If an output phase loss is detected, the VFD will trip off and identify which of the output phases is low or lost.

2.1.12 If the temperature of the VFD's heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. It shall also be possible to program the VFD so that it reduces its output current limit value if the VFD's temperature becomes too high.

2.1.13 In order to ensure operation during periods of overload, it must be possible to program the VFD to automatically reduce its output current to a programmed value during periods of excessive load. This allows the VFD to continue to run the load without tripping.

2.1.14 The VFD shall have temperature controlled cooling fan(s) for quiet operation, minimized losses, and increased VFD life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFD is running.

2.1.15 The VFD shall store in memory the last 10 alarms. A description of the alarm, and the date and time of the alarm shall be recorded.

2.1.16 When used with a pumping system, the VFD shall be able to detect no-flow situations, dry pump (ex. No Water / Loss of Prime) conditions, and operation off the end of the pump curve (ex. Under Pressure). It shall be programmable to take appropriate protective action when one of the above situations is detected.

2.2 INTERFACE FEATURES

2.2.1 Hand, Off and Auto keys shall be provided to start and stop the VFD and determine the source of the speed reference. It shall be possible to either disable these keys or password protects them from undesired operation.

2.2.2 There shall be an "Info" key on the keypad. The Info key shall include "on-line" context sensitive assistance for programming and troubleshooting.

2.2.3 The VFD shall be programmable to provide a digital output signal to indicate whether the VFD is in Hand or Auto mode. This is to alert the Building Automation System whether the VFD is being controlled locally or by the Building Automation System.

2.2.4 Password protected keypad with alphanumeric, graphical, backlit display can be remotely mounted. Two levels of password protection shall be provided to guard against unauthorized parameter changes.

2.2.5 All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs.

2.2.6 To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters. Keypad shall provide visual indication of copy status.

2.2.7 A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.

2.2.8 VFD to have start up assistance programmable with simple data for Motor, Application, Operations, Protections, and Communications for ease of commissioning.

2.2.9 A quick setup menu with factory preset typical pump parameters shall be provided on the VFD. The VFD shall also have individual Fan, and Compressor menus specifically designed to facilitate start-up of these applications.

2.2.10 The VFD's PID controller shall be able to actively adjust its setpoint based on flow. This allows the VFD to compensate for a pressure feedback sensor which is located near the output of the pump rather than out in the controlled system.

2.2.11 Floating point control interface shall be provided to increase/decrease speed in response to contact closures.

2.2.12 Five simultaneous meter displays shall be available. They shall include at a minimum, frequency, motor current, VFD output power, VFD output energy, VFD temperature in degrees, actual process variable, and setpoint among others.

2.2.13 Programmable Sleep Mode shall be able to stop the VFD. When its output frequency drops below set "sleep" level for a specified time, when an external contact commands that the VFD go into Sleep Mode, or when the VFD detects a no-flow situation, the VFD may be programmed to stop. When the VFD's speed is being controlled by its PID controller, it shall be possible to program a "restart" feedback value that will cause the VFD to start. To avoid excessive starting and stopping of the driven equipment, it shall be possible to program a minimum run time before sleep mode can be initiated and a minimum sleep time for the VFD.

2.2.14 A run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of initiating an output "run request" signal to indicate to the external equipment that the VFD has received a request to run.

2.2.15 VFD shall be programmable to display feedback signals in appropriate units, such as pressure per square inch (psi), gallons per minute (gpm), feet of water column (ft), or temperature (°F).

2.2.16 VFD shall be programmable to sense the loss of load. The VFD shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. To ensure against nuisance indications, this feature must be based on motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication.

2.3 STARTUP GENIE:

2.3.1 A Quick Set-up Genie shall be included that immediately starts upon power up.

2.3.2 The following applications shall be programmable without leaving the genie:

I. Single pump

II. Multipump up to 4 pumps
III. Duplex Mode (synchronous)
IV. Duty/Standby
V. Master/Fixed lag
VI. Speed control

2.3.3 The Genie shall only ask users to enter parameters that are required for the selected application to avoid confusion about what is required.

2.3.4 The Genie shall include an “Autoset” feature to quickly program the drive to common default values specific to the selected application type.

2.3.5 The Quick Set-up Genie shall automatically include programming for the following system safety features:

I. Flow Check
II. Sleep Speed
III. No Flow Power Detection
IV. Flow compensation
V. No water/Loss of prime
VI. Sensor Fault
VII. Under Pressure
VIII. End of curve protection
IX. Pipe fill protection
X. Over/under system pressure protection

2.3.6 Ramp times shall be selectable via the Genie and allow for Slow, Medium or Fast.

2.3.7 The Genie shall allow for multiple feedback source programming.

2.3.8 The Genie shall allow analog signals to be quickly scaled.

2.3.9 The Genie shall be easily accessed from the main menu.

2.3.10 The Genie shall allow programming for the following multi-pump operation modes:

I. Cascade control
II. Synchronous control
III. Multi Control
IV. Selectable pump Alternation by Clock hours or Run hours
V. Drives to connect via RS485

2.3.11 The IPC shall include multi-pump capabilities with redundant master and alternation over serial communication link.

2.3.12 The IPC shall include Fixed Master control that allows for single sensor control for all units.

2.4 STANDARD INPUTS AND OUTPUTS

2.4.1 Four dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.

2.4.2 Two terminals shall be programmable to act as either as digital outputs or additional digital inputs.

2.4.3 Two programmable relay outputs, Form C 240 V AC, 2 A, shall be provided for remote indication of VFD status.

I. Each relay shall have an adjustable on delay / off delay time.

2.4.4 Two programmable analog inputs shall be provided that can be either direct-or-reverse acting.

I. One shall be independently selectable to be used with either an analog current or voltage signal.
II. One shall be pre-selected for analog current (4-20mA).
III. The maximum and minimum range of each shall be able to be independently scalable from 0 to 20 mA and 0 to 10 V DC.
IV. A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise.
V. The VFD shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and troubleshooting.

2.4.5 One programmable analog current output (0/4 to 20 mA) shall be provided for indication of VFD status. This output shall be programmable to show the reference or feedback signal supplied to the VFD and for VFD output frequency, current and power. It shall be possible to scale the minimum and maximum values of this output.

2.4.6 It shall be possible through serial bus communications to read the status of all analog and digital inputs of the VFD.

2.4.7 It shall be possible to command all digital and analog output through the serial communication bus.

2.4.8 Optional Control and Monitoring Inputs and Outputs:

I. It shall be possible to add optional modules to the VFD in the field to expand its analog and digital inputs and outputs.
II. These modules shall use rigid connectors to plug into the VFD's control card.
III. The VFD shall automatically recognize the option module after it is powered up. There shall be no need to manually configure the module.
IV. Modules may include such items as:
    i. Additional digital outputs, including relay outputs
    ii. Additional digital inputs
    iii. Additional analog outputs
    iv. Additional analog inputs, including Ni or Pt temperature sensor inputs

2.4.9 It shall be possible through serial bus communications to control the status of all optional analog and digital outputs of the VFD.

2.4.10 The VFD shall be able to store load profile data to assist in analyzing the system demand and energy consumption over time.

2.4.11 The VFD shall include a sequential logic controller to provide advanced control interface capabilities. This shall include:

I. Comparators for comparing VFD analog values to programmed trigger values

II. Logic operators to combine up to three logic expressions using Boolean algebra
III. Delay timers
IV. A 20-step programmable structure

2.4.12 The VFD programming shall include a “Duplex Mode” which allows 2 VFD’s to operate in closed loop set point (PID) control mode in parallel with two motors at synchronous speed to satisfy system setpoint. Duplex VFD shall be programmed through specific start-up assistance for lead and lag pump with alternation based upon clock time or duty standby with alternation based upon clock time.

2.4.13 The VFD shall include a Cascade Controller which allows the VFD to operate in closed loop set point (PID) control mode one motor at a controlled speed and control the operation of 2 additional constant speed motor starters.

2.5 SERIAL COMMUNICATIONS

2.5.1 The VFD shall include a standard EIA-485 communications port and capabilities to be connected to the following serial communication protocols at no additional cost and without a need to install any additional hardware or software in the VFD:
I. BACnet MSTP
II. Modbus RTU
III. Johnson Controls Metasys N2

2.5.2 VFD shall have standard USB port for direct connection of Personal Computer (PC) to the VFD. The manufacturer shall provide no-charge PC software to allow complete setup and access of the VFD and logs of VFD operation through the USB port. It shall be possible to communicate to the VFD through this USB port without interrupting VFD communications to the building management system.

2.5.3 The VFD shall have provisions for an optional 24 V DC back-up power interface to power the VFD’s control card. This is to allow the VFD to continue to communicate to the building automation system even if power to the VFD is lost.

2.6 ADJUSTMENTS

2.6.1 The VFD shall have a manually adjustable carrier frequency that can be adjusted in 0.5 kHz increments to allow the user to select the desired operating characteristics. The VFD shall also be programmable to automatically reduce its carrier frequency to avoid tripping due to thermal loading.

2.6.2 Four independent setups shall be provided.

2.6.3 Four preset speeds per setup shall be provided for a total of 16.

2.6.4 Each setup shall have two programmable ramp up and ramp down times. Acceleration and deceleration ramp times shall be adjustable over the range from 1 to 3,600 seconds.

2.6.5 Each setup shall be programmable for a unique current limit value. If the output current from the VFD reaches this value, any further attempt to increase the current produced by the VFD will cause the VFD to reduce its output frequency to reduce the load on the VFD. If desired, it shall be possible to program a timer which will cause the VFD to trip off after a programmed time period.

2.6.6 If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: external interlock, under-voltage, over-voltage, current limit, over temperature, and VFD overload.

2.6.7 The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.

2.6.8 An automatic “start delay” may be selected from 0 to 120 seconds. During this delay time, the VFD shall be programmable to either apply no voltage to the motor or apply a DC braking current if desired.

2.6.9 Four programmable critical frequency lockout ranges to prevent the VFD from operating the load at a speed that causes vibration in the driven equipment shall be provided. Semi-automatic setting of lockout ranges shall simplify the set-up.

2.7 SERVICE CONDITIONS

2.7.1 Ambient temperature, continuous, full speed, full load operation:

I. -10 to 45°C (14 to 113°F) through 600 HP @ 460 and 600 volt, through 60 HP @ 208 volt
II. -10 to 40°C (14 to 104°F) 150 HP and larger

2.7.2 0 to 95% relative humidity, non-condensing.

2.7.3 Elevation to 3,300 feet without derating.

2.7.4 AC line voltage variation, -10 to +10% of nominal with full output.

2.7.5 No side clearance shall be required for cooling.

2.7.6 All power and control wiring shall be done from the bottom.

2.7.7 All VFDs shall be plenum rated.

2.8 QUALITY ASSURANCE

2.8.1 To ensure quality, the complete VFD shall be tested by the manufacturer. The VFD shall drive a motor connected to a dynamometer at full load and speed and shall be cycled during the automated test procedure.

2.8.2 All optional features shall be functionally tested at the factory for proper operation.

2.9 SUBMITTALS

2.9.1 This specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from the specification are identified, the supplier shall be bound by the specification.

PART 3 - EXECUTION

3.0 WARRANTY

The complete VFD shall be warranted by the manufacturer for a period of thirty six (36) months from the date of installation or forty two (42) months from the product date code, whichever shall occur first. The warranty shall be provided by the VFD manufacturer and not a third party.