

**Standard Specification for PS220 Cabinet (floor standing enclosure)  
Low Harmonic Adjustable Speed Drives  
Rated from 250 to 4250 HP at 480 to 690 VAC**

**Part 1 - GENERAL**

1.01 DESCRIPTION

- A. This specification describes a complete Adjustable Speed AC Drive (ASD) used to control the speed and torque of NEMA design B induction motors used in areas where low harmonic content is desired or mandated.
- B. The ASD manufacturer shall supply the ASD and all necessary controls as herein specified.
- C. The ASD shall be manufactured by a company with at least twenty (10) years of experience in the production of this type of equipment.

1.02 QUALITY ASSURANCE

- A. The ASD manufacturing facility shall be ISO 9001 and ISO 14001 certified.
- B. All printed circuit boards shall be completely tested before being assembled into the complete ASD. The ASD shall be subjected to a functional test and load test. The load test shall be at full rated load, or cycled load.
- C. The ASD manufacturer shall have an analysis laboratory to evaluate the failure of any component.

1.03 QUALIFICATIONS

- A. The ASD shall meet the following specifications:
  - UL 508A and/or 508C - Underwriter's Laboratory. The ASD shall be UL listed and carry the UL mark.
  - CAN/CSA-C22 No. 14-M91 - Canadian Standards Association. The ASD shall be C-UL or CSA listed and carry the appropriate mark.
  - 1. Institute of Electrical and Electronic Engineers (IEEE). Standard 519-1992, IEEE Guide for Harmonic Content and Control.

The ASD shall comply with the following European Union's CE directives and shall carry the CE mark:

- EMC Low Voltage Directive 73/23 EEC
- EMC Directive 89/336 EEC
- Machinery Directive 98/37 EC

- B. Acceptable manufacturers:

- 1. ITT Goulds Pumps PS220 series of AC ASDs
- 2. ABB Inc. ACS880 series of AC ASDs
- 3. ASD manufacturer shall: design, manufacture, quality control and life cycle manage all products offered on this project.
- 4. ASD vendors that brand label products manufactured by others shall not be allowed.

## 1.04 SUBMITTALS

A. The Submittals shall include the following information:

1. Outline dimensions and weight.

- Customer connection and power wiring diagrams.
- Complete technical product description including a complete list of options provided.
- Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD). The ASD manufacturer shall provide calculations; specific to the installation, showing total harmonic voltage distortion is less than 5%. Input filters shall be sized and provided as required by the ASD manufacturer to ensure compliance with the IEEE electrical system standard 519. All ASDs shall include a minimum of 3% equivalent impedance reactors, **no exceptions**

**Part 2 - DESIGN**

## 2.01 DESCRIPTION

A. The ASD shall be a solid state AC to AC inverter controlled device utilizing the latest isolated gate bipolar transistor (IGBT) technology. The ASD shall utilize Direct Torque Control (DTC) as the primary motor control, employing an inner loop torque control strategy that mathematically determines the optimal motor torque and flux every 25 microseconds. The ASD shall also provide an optional motor control operational mode for scalar of V/Hz operation.

B. The benefits that the motor control DTC shall make available for the operation of a NEMA design B induction motor shall be:

1. Steady state speed accuracy within 1/10th the slip without an encoder, for process repeatability.
2. 100% motor torque from zero speed available for acceleration with the ASD continuous current rating equal to or greater than the motor full load amp rating.
3. At and below 90% speed, 100% torque is achievable even with 10% low line voltage.
4. Ability to limit torque to protect the mechanical system with a common single torque setting above and below field weakening.
5. Ability to provide torque in % of motor shaft torque (within +/- 4% linearity) on the ASD control panel, analog output or via field bus of actual.
6. Quiet motor operation for audibly friendly working environment in comparison to other low voltage PWM solutions utilizing a carrier frequency.
7. Have available the ability to operate in open loop torque control, with an ability to switch between speed and torque control on the fly with the change of state to a digital input.
8. Have an ability to share load or speed between two or more induction AC motors connected to the same system, when those motors are controlled by separate ASDs.

C. The ASD shall be an Ultra Low Harmonic Adjustable Speed AC Drive that is designed to comply with standard IEEE 519-1992 when installed into system that already is in compliance with the standard.

## 2.02 HARMONICS

A. The Ultra Low Harmonic construction of the ASD shall not contribute any significant harmonics at the input terminals of the ASD, and shall maintain harmonics levels at the ASD's input terminals to levels at or below those listed in "Harmonic Control in Electrical Power Systems, IEEE Std. 519-1992." in the system that already is in compliance with the said standard.

- B. All harmonic management devices must be internal to the ASD enclosure and supplied as a complete solution.
- C. The ASD shall have an active line supply unit which controls the waveform of the input current and reduces the low order harmonic current drawn from the power line. Line currents and voltages shall be nearly sinusoidal. IGBTs shall be used in the rectified and inverter circuits.
- D. Each input phase of the ASD shall incorporate a symmetrical LCL filter arranged in a T-configuration. The inductors are to be series power components that carry the full current of the ASD.
- E. The input current to the ASD shall have a total harmonic content less than 5% of full rated capability at the input terminals of the ASD on power system sized according to IEEE 519-1992 at line voltage unbalance up to 3% and under all motor load conditions.
- F. The ASD shall operate at fundamental power factor 1.0 on the supply side under all motor load conditions.
- G. The input power factor shall be programmable from 0.8 lagging to 0.8 leading, allowing the ASD to be used as a compensating device for installations that are excessively inductive or excessively capacitive in reactive power. The reactive power required by other loads connected to the same distribution system may be compensated for by the providing that ASD has sufficient capacity for reactive and active loads.
- H. The ASD's design shall not compensate for existing harmonic content in the distribution system.

## 2.03 RATINGS

- A. The ASD shall be rated to operate from 3-phase power at 380 to 690 VAC +10/-10%. The overvoltage trip level shall be a minimum of 30% over nominal, and the undervoltage trip level shall be a minimum 35% under the nominal voltage.
- B. The ASD shall be rated to operate at the following environmental operating conditions:
  - 1. Ambient temperature 0 to 40°C continuous and up to 50°C continuous with a derating factor.
  - 2. Altitude 0 to 3300 feet above sea level without derating, less than 95% humidity, non-condensing.
- C. The ASD shall be offered from 250 to 4250 HP in similar construction and operation, using the same technology.
- D. The ASD shall be rated to operate from input power from 48Hz to 63Hz.
- E. Output voltage and current ratings shall match the adjustable frequency operating requirements of standard NEMA design A or NEMA design B motors.
- F. The Light Duty overload current capacity shall be 110% of rated current for one (1) minute out of five (5) minutes.
- G. The Heavy Duty overload current capacity shall be 150% of rated current for one (1) minute out of five (5) minutes.
- H. The ASD efficiency shall be 98% or better of the full rated capability of the ASD at full speed and load. In case an alternative low harmonics solution is offered, the overall efficiency of the ASD and the harmonic mitigation components shall meet the efficiency requirement.

## 2.04 CONSTRUCTION

- A. All models shall provide a complete, ready-to-install solution.

- B. The latest, most efficient IGBT power technology shall be used. This technology shall be used for all power and voltage ranges offered by the manufacturer.
- C. The ASD shall offer microprocessor based control logic that is isolated from power circuitry.
- D. Control connections shall remain consistent for all power ratings.
- E. The ASD shall employ an active AC to DC rectifier (commonly referred to as an active supply unit).
- F. Cabinet ASDs shall be available from 250 to 4250 HP and have the following features:
  - 9. Offered in UL Type 1 and UL Type 12 with filter and forced air enclosures.
    - Include a control panel mounted on the front of the ASD enclosure door.
    - Single point power connections per each electrical phase.
    - Include integrated internal AC line reactor or DC choke.
    - Include input disconnect or Molded Case Circuit Breaker (MCCB) with through the door interlock lockable in the off position.
    - Include high speed input AC line fuses for protection of the input bridge.
    - Offer option internally mounted braking chopper for use in dynamic braking.
    - Common mode filter standard above 250 HP.
- G. Desired optional features shall be furnished and mounted by the ASD manufacturer and shall also be available as field installable kits as an alternative. All optional features shall carry all of the necessary certifications as described in Section 1.03. Field installed kits shall not affect the ASD's certification.

## 2.05 OPERATOR INTERFACE

- H. The ASD shall be equipped with a front mounted operator control panel consisting of:
  - 1. A four- (4) line back-lit alphanumeric LCD display that is 240x160 pixels.
  - 2. Configurable displays showing, bar graph and meter.
  - 3. Keypad with keys for Run/Stop, Local/Remote, Increase/Decrease, Reset, Menu navigation and Parameter select/edit.
- I. The control panel shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple ASDs.
- J. The display of the control panel shall have the following features:
  - 1. All parameter names, fault messages, warnings and other information shall be displayed in complete American English words or standard American English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross-reference table.
  - 2. Additional languages including French, Spanish, Portuguese, German, Italian, Dutch, Danish, Swedish, Finnish, Russian, Turkish and Chinese shall be selectable.
  - 3. During normal operation, one (1) line of the control panel shall display the speed reference, and run/stop forward/reverse and local/remote status. The remaining three (3) lines of the display shall be programmable to display the values of any three (3) operating parameters. The selection shall include at least the following values:
    - I. Speed/torque in percent (%), RPM or user-scaled units.
    - II. Output frequency, voltage, current and torque.
    - III. Power and kilowatt hours.
    - IV. Heatsink temperature and DC bus voltage.
    - V. Status of discrete inputs and outputs.
    - VI. Values of analog input and output signals.
    - VII. Values of PID controller reference, feedback and error signals.

- K. The control panel shall be used for local control, for setting all parameters, and for stepping through the displays and menus.
- L. A copy function to upload and store parameter settings from an ASD and download stored parameter settings to the same ASD or to another ASD shall exist.
- M. Intelligent configuration wizards shall be provided as standard, and are used automatically set up the VFD for most common applications. By answering a few application questions the wizard will parameterize the VFD for that operation. A minimum of the following wizards are required.
  - 1. Basic Start Up (speed control)
  - 2. Process Control
  - 3. SmartFlow
  - 4. Pump Protection
  - 5. Multipump
  - 6. Water/Wastewater Functions
  - 7. Multivariable Setup
  - 8. I/O Configuration
  - 9. Parameter Restore
- N. The display shall have a real time clock and calendar for the purpose of displaying time and date stamped faults and warnings.
- O. Additional keypad features shall include the following;
  - 1. A mini USB connection port shall be located on the keypad for the purpose of capturing various screens to a standard computer.
  - 2. Up to 21 home screens enabling the user to predefine personalized screens for multiple specific operations.
  - 3. Trend capability
  - 4. Status LED (faults and warnings)
  - 5. Multifunction softkeys

## 2.06 PROTECTIVE FEATURES

- A. For each programmed warning and fault protection function, the ASD shall display a message in complete English words or Standard English abbreviations. The ASD shall be capable of displaying up to five (5) active faults and store the previous five (5) non-active faults and provide a real time stamp when they occurred. The ASD shall provide a help feature to further explain the displayed fault.
- B. The ASD shall include internal MOV's for phase to phase and phase to ground line voltage transient protection.
- C. Output short circuit and ground fault protection rated for 100,000 amps shall be provided per UL508A.
- D. Motor phase loss protection shall be provided.
- E. The ASD shall provide electronic motor overload protection qualified per UL508C.
- F. Protection shall be provided for AC line or DC bus overvoltage at 130% of maximum rated voltage or undervoltage at 65% of min. rated voltage.
- G. The ASD shall protect itself against input phase loss.
- H. Power loss ride through feature shall allow the ASD to remain fully operational after losing power as long as kinetic energy can be recovered from the rotating mass of the motor and load.

- I. Stall protection shall be programmable to provide a warning or stop the ASD after the motor has operated above a programmed torque level for a programmed time limit.
- J. Underload protection shall be programmable to provide a warning or stop the ASD after the motor has operated below a selected underload curve for a programmed time limit.
- K. Over-temperature protection shall provide a warning if the power module temperature is less than 5°C below the over-temperature trip level.
- L. Input terminals shall be provided for connecting a motor thermistor (PTC type) to the ASD's protective monitoring circuitry. An input shall also be programmable to monitor an external relay or switch contact.

## 2.07 CONTROL INPUTS AND OUTPUTS

### A. Discrete Inputs

- 1. Minimum of six (6) discrete inputs shall be provided.
- 2. Minimum of six (6) shall be independently programmable with function selections (run/stop, hand-off-auto, etc.).

Inputs shall be designed for use with either the ASD's internal 24 VDC supply or a customer supplied external 24 VDC supply.

### B. Discrete outputs

- 1. Minimum of two (2) form C relay contact outputs shall be provided  
All outputs shall be independently programmable to activate with at least 30 function selections including;
  - I. Operating conditions such as drive ready, drive running, reversed and at set speed
    - General warning and fault conditions.
    - Adjustable supervision limit indications based on programmed values of operating speed, speed reference, current, torque, and PID feedback.
    - Relay contacts shall be rated to switch 2 Amps at 24 VDC or 115/230 VAC.

### C. Analog Inputs

- 1. Minimum of two (2) analog inputs shall be provided:
  - I. Two (2) shall be selectable for either a current or a voltage input.
    - Resolution of analog inputs shall be at least 11bit total resolution.
    - Inputs shall be independently programmable to provide signals including speed / frequency reference, torque reference or set point, PID set point and PID feedback / actual.
    - A differential input isolation amplifier shall be provided for each input.
    - Analog input signal processing functions shall include scaling adjustments, adjustable filtering and signal inversion.

If the input reference is lost, the ASD shall give the user the option of the following (the ASD shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus):

- I. Stopping and displaying a fault.
  - Running at a programmable preset speed.
  - Hold the ASD speed based on the last good reference received.
  - Cause a warning to be issued, as selected by the user.
  - When inputs are used as speed references, reference signal processing shall include increase/decrease floating point control and control of speed and direction using a "joystick" reference signal. Two (2) analog inputs shall be programmable to form a

reference by addition, subtraction, multiplication, minimum selection or maximum selection.

- D. Analog Outputs
  - 1. Minimum of two (2) 0 / 4-20 mA analog outputs shall be provided. Outputs shall be independently programmable to provide signals proportional to output function selections including output speed, frequency, voltage, current and power.
- E. Digital Inputs/Outputs
  - 1. Minimum of two (2) digital inputs/outputs shall be provided.
  - 2. Minimum of one (1) can be programmed as a frequency input.
  - 3. Minimum of one (1) can be programmed as a frequency output.
- F. Safety Inputs
  - 1. A Safe Torque Off (STO) terminal shall be integrated in the drive as a standard.
  - 2. The STO function shall meet a Safety Integrity Level (SIL) 3 and a Performance Level (PL) e.
  - 3. The STO function shall be certified by a third party approval agency e.g. TUV Nord.

## 2.08 SERIAL COMMUNICATIONS

- A. The ASD shall be capable of communicating with other ASDs or controllers via a serial communications link. A variety of communications interface modules for the typical overriding control systems shall be available.
- B. Interface modules shall be available for a wide selection of protocols including but not limited to:
  - 1. Modbus
  - 2. Ethernet IP
  - 3. ModBus TCP
  - 4. ControlNet
  - 5. DeviceNet
  - 6. Profibus
  - 7. ProfiNet
- C. Interface modules shall mount directly to the ASD control board or be connected via fiber optic cables to minimize interference and provide maximum throughput.
- D. I/O shall be accessible through the serial communications adapter. Serial communication capabilities shall include, but not be limited to:
  - 1. Run-Stop control
  - 2. Hand-Off-Auto Control
  - 3. Speed Adjustment
  - 4. PID (proportional/integral/derivative) control adjustments
  - 5. Current Limit
  - 6. Accel/Decel time adjustments
- E. The ASD shall have the capability of allowing the overriding controller to monitor feedback such as process variable feedback, output speed/frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), relay outputs, and diagnostic warning and fault information.
- F. A connection shall also be provided for personal computer interface. Software shall be available for ASD setup, diagnostic analysis, monitoring and control. The software shall provide real time graphical displays of ASD performance.

2.09 CONTROL FUNCTIONS AND ADJUSTMENTS

- A. Output frequency shall be adjustable from 0 to 500 Hz. Operation above motor nameplate shall require programming changes to prevent inadvertent high-speed operation.
- B. Stop mode selections shall include coast to stop and ramp to stop.
- C. The ASD shall be capable of controlling deceleration of a load without generating an overvoltage fault caused by excessive regenerated energy. Overvoltage control on deceleration shall extend the ramp time beyond the programmed value to keep the amount of regenerated energy below the point that causes overvoltage trip.
- D. The ASD shall be capable of controlling a rotating motor regardless of the motor direction. From the time the start signal is given to the ASD to the time the ASD has control of the motor shall not exceed two (2) seconds. Once the ASD has control of the motor it will then accelerate or decelerate the motor to the active reference speed without tripping or faulting or causing component damage to the ASD. The ASD shall also be capable of flux braking at start to stop a reverse spinning motor prior to ramp.
- E. The ASD shall have the ability to automatically restart after an overcurrent, overvoltage, undervoltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between reset attempts shall be programmable.
- F. Control functions shall include two (2) sets of acceleration and deceleration ramp time adjustments with linear and an s-curve ramp time selection.
- G. Speed control functions shall include:
  - 1. Adjustable min/max speed limits.
  - 2. Selection of up to 15 preset speed settings for external speed control.
  - 3. Three sets of critical speed lockout adjustments.
  - 4. A built-in PID controller to control a process variable such as pressure, flow or fluid level.
- H. Functions shall include flux optimization for optimizing energy efficiency and limit the audible noise produced by the motor by providing the optimum magnetic flux for any given speed / load operating point.
- I. The ASD shall be capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. The ASD shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay output shall include programmable time delays that will allow for ASD acceleration from zero speed without signaling a false underload condition.
- J. Three (3) programmable critical frequency lockout ranges shall be provided to prevent the ASD from operating the load continuously at an unstable speed.
- K. The ASD shall offer software to select the ASD's action in the event of a loss of the primary speed reference.

**Part 3 - CONTROLS & PROGRAMMING**

3.01 General Application Program

- 1. All logic set forth in this specification must reside internal to the VFD's internal microprocessor. If an external controller is required it must be clearly stated and included in the base bid.
- 2. VFD shall be preprogrammed with a pump specific application macros.



3. The VFD shall use pump specific wizards to guide the user through the process of setting up most common pump functions. At the completion of a wizard the VFD must automatically configure itself for that specific functionality. At a minimum the VFD must contain the following wizards:
  - a. Basic Start Up (speed control)
  - b. Process Control
  - c. SmartFlow
  - d. Pump Protection
  - e. Multipump
  - f. Water/Wastewater Functions
  - g. Multivariable Setup
  - h. I/O Configuration
  - i. Parameter Restore
4. The Control Panel (keypad) should have the ability to display pump nomenclature (PSIG, GPM, IP/s, mm/s, etc.) to allow the operator to have a better understanding of the current pump and system status.
5. VFD shall have an internal Proportional/Integral/Derivative (PID) control algorithm to control a process variable such as pressure, flow, level, temperature, etc. The PID controller should be able to regulate speed or torque to accurately control the process variable.
  - a. The VFD shall recognize system low demand and have the option to automatically shut down in a suspended sleep mode until the process demand requires the pump to turn back on.
6. The VFD system shall have the ability to perform process control (PID) using either motor speed, or motor torque, as the manipulated variable.
7. The VFD shall have the ability to follow a speed reference through the VFD's keypad, an analog input or serial bus command.
8. A second PID control algorithm is to be available for the purpose of enabling the drive to conduct two different PID functions.

### 3.02 Multipump Operation

1. The VFD shall include a Multipump Macro, set up by using a wizard, which will permit up to 6 VFDs to communicate on a peer-to-peer (drive to drive) network for the purpose of staging on and off up to 6 pumps. One drive will operate one pump.
2. Multipump operation shall be functional for any PID control operation.
3. Drive to drive communication shall be over a dedicated industrialized RS485 serial communications network. This network must be integrated into the base VFD and not require a separate communications module.
4. The VFD shall control to a single process variable and automatically stage and de-stage pumps on and off depending on the process demand. The settings at which the pumps are staged and de-staged shall be field adjustable through the VFD's standard keypad.
5. Staging can be operator set to be dependent on pump speed and error, or on process value.
6. In the event of a VFD, motor, or pump fault the Multipump system will recognize this failure and shall automatically start the next available pump when required.

7. When multipump pumps are running the VFDs shall synchronize in speed to ensure the pumps share the load evenly.
8. In the event a pump is demonstrating wear and is not able to share the load equally a synchronous torque option will be available. This option will synchronize the torques of all the running pumps to help evenly distribute the load over all the running pumps. The motors shall be identical on all the pumps running in synchronous torque mode.
9. The VFDs shall alternative the operation of the pumps based on one or both of the following criteria.
  - a. Operating hours
  - b. Number of sleeps
10. The VFD shall have a pressure boost function to compensate for additional system friction losses at higher flow rates. This function shall automatically increase the pressure setpoint when additional pumps are staged on. Alternatively the pressure setpoint will decrease as pumps are de-staged off.
11. The Multipump operations must permit the user to limit the maximum number of pumps that may run at any one time or the minimum number of pumps that may run at any one time.
12. The Multipump operation must offer the security of a roaming lead where if the designated lead pump fails a subsequent VFD will become the lead for the purpose of maintaining Multipump operation.

### 3.03 Flow Estimation

1. The VFD shall have the ability to estimate the pump flow to an accuracy of  $\leq \pm 5\%$  of the total rated pump flow through a variable speed range of 50%-100% of the motor synchronous speed and without external process transmitters for pumps with a specific speed under 3000. For pumps with a specific speed greater than 3000 then it is permitted to add a differential transmitter across the pump to assist in calculating flow.
2. When flow estimation is used in conjunction with Multipump operation the total estimated flow must be available to the lead VFD for proper PID operation.
3. The flow calculation algorithm shall be operational using commonly available pump performance curves. Factory performance tests shall not be required to attain the flow accuracy.
4. The flow calculation algorithm shall have the ability to be field calibrated without requiring field instrumentation.
5. ( ) When checked; the flow calculation logic shall be capable of correcting for a changing specific gravity via a 4-20 mA signal, serial buss communication, or corrected via temperature transmitter input.
6. ( ) When checked; The flow calculation logic shall be capable of calculating pump flow on a magnetic drive pump with a metal containment shell.

### 3.04 Flow Based Features

1. The VFD shall include an integrated flow totalizer which may totalize based on the sensorless flow estimator value or the input of a flow transmitter.
2. The VFD shall have the ability to use an external flow transmitter or the sensorless calculated flow value for the purpose of batch operations, where at a preset value the VFD will take action to shut down the pump.
3. The VFD shall have the ability to calculate real time percent of Best Efficiency Point (BEP) and display this value on the display.
4. The VFD shall have the ability to estimate the Total Dynamic Head (TDH) of the pump and display this value on the keypad display.

5. The VFD shall have a minimum flow rate bypass capability for when the flow rate is less than the pump's min flow value. When below minimum flow is detected a digital output of the VFD shall turn on to operate a flow bypass valve. The bypass valve should turn off when the flow rate exceeds a preset flow value above the pump's minimum flow rate.

### 3.05 Pump Protection

1. Pump Protection – The VFD shall have the ability to warn and/or protect the pump against process upset conditions of dry-running (severe cavitation), operation below recommended minimum flow, and operation past recommended maximum flow throughout the anticipated variable speed range and without the need for external process transmitters.
  - a. The pump protection feature shall be easily set-up using values of flow (GPM or M3/hr).
  - b. The pump protection feature shall have the ability to offer control reactions specific to the condition:
    - c. Dry-Run: Warn only, Warn & Stop
    - d. Min-Flow: Warn only, Warn & Control to Min Speed
    - e. Max-Flow: Warn only
  - f. The protection logic shall account for changing load profiles due to changes in speed, including mechanical and hydraulic losses
  - g. The protection logic shall not false trip when the drive is reducing speed in normal control modes.
  - h. ( ) When checked; The protection logic shall be capable of calculating pump flow on a magnetic drive pump with a metal containment shell.

### 3.06 Flow Economy

1. Flow Economy – The VFD shall have the ability to calculate the Flow Economy ratio of pump flow divided by electrical input power.
  - a. The pump flow shall be calculated using a sensorless flow function integral to the VFD.
  - b. The electrical power input shall be the true electrical power consumption which includes all VFD and motor losses.
  - c. The Flow Economy Ratio shall be a selectable parameter on the VFD's keypad and shall be available through a 4-20mA output or through a serial bus register.

### 3.07 Condition Monitoring

1. VFD shall have the capability to monitor up to two (2) channels of information. These channels shall be either an external 4-20mA / 0-10VDC analog inputs or a minimum of 13 internal VFD and pump signals.
  - a. The keypad display should clearly indicate the units of the condition monitored such as Amps, Hz, IP/s or mm/s etc.
  - b. The VFD will have two programmable levels for a high condition and two programmable levels for low levels to signal a warning and alarm.
  - c. In the event the event the alarm level is reached VFD shall have the option to signal an alarm, go to a safe predetermined minimum speed, fault the pump or go into a suspended sleep mode until the level is restored above normal.

## 3.08 Cavitation Control

1. The VFD shall have the ability to monitor the suction conditions of a pump and react to prevent the onset of pump cavitation.
2. The VFD shall have the ability to monitor an external analog signal from either a suction pressure or level transmitter.
  - a. When the suction conditions of the pump reach a critical low level the VFD will slow down to reduce the NPSH requirement of the pump.
  - b. The intensity at which the VFD reduces the pump speed shall be configurable to the specific application.
3. The VFD shall resume normal operation above the low level limit threshold.

## 3.09 Water & Waste Water Functions

1. The VFD shall have a Pump Cleaning sequence with the following features.
  - a. Initiation of the sequence is based on the ability to detect a blockage in the pump using sensorless speed and torque measurements.
  - b. On detection of this blockage the pump shall enter into a Pump Cleaning Sequence. This sequence includes running the pump in a programmed designed to clear blockages. This program includes running the pump in forward and reverse directions until the blockage is cleared.
  - c. If the blockage cannot be cleared the drive shall fault the pump and clearly identify the pump has faulted dues to blockage.
  - d. The VFD supplier shall verify with the pump manufacturer the pump is suitable to run in reverse rotation.
2. The VFD shall have a Pipe Fill sequence for the purpose of preventing run out due to the lack of back pressure.
  - a. Initiation of the pipe fill sequence shall cause the pump to run at a safe user set speed prior to the VFD returning to its normal operation (PID or speed control).
3. The VFD shall include a Snore sequence for the purpose of removing floating debris.
  - a. The Snore sequence will cause the pump to drain the sump at periodic intervals for the purpose of removing floating debris.
4. The VFD shall have a Pipe Cleaning sequence for the purpose of flushing the pipe system in an effort to reduce sedimentation buildup in the pipe.

## Part 4 - OPTIONS

### 4.01 Cabinet ASDs from 250 to 4250 HP

1. UL Type 12 (IP55) enclosure.
2. Bottom Entry and/or Exit of power and control cables.
3. Prevention of unexpected start through the use of redundant and non-processor based control complying with SIL3 (Safety Integrity Levels) as per IEC 61508.
4. Input AC line contactor and E-Stop category 0 or category 1.
5. Second Environment EMC / RFI filter

6. Input and Output extension modules:
  - a. Analog input and output expansion.
  - b. Digital input and output expansion.
  - c. Speed and position feedback for TTL incremental encoder.
  - d. Speed and position feedback for resolver interface.
  - e. Fieldbus communication modules (protocols):
    - I. DeviceNet
    - II. ControlNet
    - III. EtherNet / IP
    - IV. ModBus TCP
    - V. ModBus
    - VI. ProfiBus DP
    - VII. ProfiNet

## Part 5 - WARRANTY

### 5.01 VFD Warranty

1. VFDs shall be warrantied against any and all defects in craftsmanship and materials for a time of 18 months from date of shipment. Faulty VFDs may be repaired on site or may be sent back to the factory for repair based on the supplier's recommendation.

### 5.02 Reliability Guarantee

1. The pump, motor and VFD are required to be warrantied for a period of 36 months from the date of commissioning not to exceed 42 months from the date of shipment for new pump installations and at least 18 month for existing pump installations.
  - a. The pump is to be warrantied against damage due to process related upset conditions (dry run, minimum flow, and run out) and shall cover parts only. Labor, shipping, and in/out costs are not part of this warranty.
  - b. The VFD warranty shall be 36 months from date of shipment, and shall cover parts and repair labor only. In/out costs are not covered under this extended warranty. Faulty VFDs may be repaired on site or may be sent back to the factory for repair based on the supplier's recommendation.

## Part 6 - EXECUTION

### 6.01 INSTALLATION

- A. The ASD manufacturer shall provide adequate drawings and instruction material to facilitate installation of the ASD by qualified electrical and mechanical personnel employed by others.

### 6.02 START-UP

- A. Certified factory start-up shall be provided for each ASD by a factory authorized service center. A certified start-up form shall be filled out for each ASD with a copy provided to the owner, and a copy kept on file at the manufacturer.
- B. The factory will extend the normal warranty for the ASD with a certified factory start-up.

**6.03 PRODUCT SUPPORT**

- A. Factory trained application engineering and service personnel that are thoroughly familiar with the ASD products offered shall be locally available at both the specifying and installation locations.
- B. A 24/365 technical support line shall be available on a toll-free-line.

**6.04 WARRANTY**

- A. Standard Warranty shall be 12 months from the date of start-up, not to exceed 18 months from the date of shipment. The warranty shall include all parts.
- B. With a certified start-up (applicable in the USA and Canada only), warranty shall be 24 months from the date of start-up, not to exceed 30 months from the date of shipment. The warranty shall include all parts, labor, travel time, and expenses.
- C. There shall be 24/365 support available on a toll-free-line.