Hydro MPC-E HVAC (Panel Mount VFD) Guide Specification

Part I – GENERAL

1.1 WORK INCLUDED

    A. Variable Speed Packaged Pumping System

1.2 REFERENCE STANDARDS

The work in this section is subject to the requirements of applicable portions of the following standards:

    A. Hydraulic Institute
    B. ANSI – American National Standards Institute
    C. ASTM – American Society for Testing and Materials
    D. IEEE – Institute of Electrical and Electronics Engineers
    E. NEMA – National Electrical Manufacturers Association
    F. NEC – National Electrical Code
    G. ISO – International Standards Organization
    H. UL – Underwriters Laboratories, Inc.

Part 2 – PRODUCTS

2.1 VARIABLE SPEED PACKAGED PUMPING SYSTEM

A. Furnish and install a pre-fabricated and tested variable speed packaged pumping system to maintain constant water delivery pressure.

B. The packaged pump system shall be a standard product of a single pump manufacturer. The entire pump system including pumps and pump logic controller, shall be designed, built, and tested by the same manufacturer.

C. The complete packaged water booster pump system shall be certified and listed by UL (Category QCZJ – Packaged Pumping Systems) for conformance to U.S. and Canadian Standards.

D. The complete packaged pumping system shall be NSF61 / NSF372 Listed for drinking water and low lead requirements.

E. The packaged pump system shall be ASHRAE 90.1 – 2010 compliant without the need of a remote mounted sensor. The control logic used to simulate a remote mounted sensor shall be proportional pressure control with squared or linear adaptation. An actual flow rate or calculated flow rate based on performance curves (5th order polynomial) loaded into the controller; shall be used to adjust setpoint pressure in proportional pressure control.

2.2 PUMPS

A. The pumps shall be of the in-line vertical multi-stage design.

B. The head-capacity curve shall have a steady rise in head from maximum to minimum flow within the preferred operating region. The shut-off head shall be a minimum of 20% higher than the head at the best efficiency point.

C. Small Vertical In-Line Multi-Stage Pumps (Nominal flow from 3 to 125 gallons per minute) shall have the following features:

    1. The pump impellers shall be secured directly to the pump shaft by means of a splined shaft arrangement.

2. The suction/discharge base shall have ANSI Class 250 flange or internal pipe thread (NPT) connections as determined by the pump station manufacturer.

3. Pump Construction.

    a. Suction/discharge base, pump head, motor stool: Cast iron (Class 30)
    b. Impellers, diffuser chambers, outer sleeve: 304 Stainless Steel
    c. Shaft   316 or 431 Stainless Steel
    d. Impeller wear rings: 304 Stainless Steel
    e. Shaft journals and chamber bearings: Silicon Carbide
    f. O-rings: EPDM

Shaft couplings for motor flange sizes 184TC and smaller shall be made of cast iron or sintered steel. Shaft couplings for motor flange sizes larger than 184TC shall be made of ductile iron (ASTM 60-40-18).

Optional materials for the suction/discharge base and pump head shall be cast 316 stainless steel (ASTM CF-8M) resulting in all wetted parts of stainless steel.

4. The shaft seal shall be a balanced o-ring cartridge type with the following features:

    a. Collar, Drivers, Spring: 316 Stainless Steel
    b. Shaft Sleeve, Gland Plate: 316 Stainless Steel
    c. Stationary Ring: Silicon Carbide
    d. Rotating Ring: Silicon Carbide
    e. O-rings: EPDM

The Silicon Carbide shall be imbedded with graphite.

5. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, shaft coupling and motor. The entire cartridge shaft seal shall be removable as a one piece component. Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

D. Large In-line Vertical Multi-Stage Pumps (Nominal flows from 130 to 500 gallons per minute) shall have the following features:

1. The pump impellers shall be secured directly to the smooth pump shaft by means of a split cone and nut design.

2. The suction/discharge base shall have ANSI Class 125 or Class 250 flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.

3. Pump Construction.

    a. Suction/discharge base, pump head   Ductile Iron (ASTM 65-45-12)
    b. Shaft couplings, flange rings: Ductile Iron (ASTM 65-45-12)
    b. Shaft   431 Stainless Steel
    c. Motor Stool   Cast Iron (ASTM Class 30)
    d. Impellers, diffuser chambers, outer sleeve: 304 Stainless Steel
    e. Impeller wear rings: 304 Stainless Steel
    f. Intermediate Bearing Journals: Silicon Carbide
    g. Intermediate Chamber Bearings: Leadless Tin Bronze
    h. Chamber Bushings: Graphite Filled PTFE
    I. O-rings: EPDM

4. The shaft seal shall be a balanced o-ring cartridge type with the following features:

a. Collar, Drivers, Spring:	316 Stainless Steel
b. Shaft Sleeve, Gland Plate:	316 Stainless Steel
c. Stationary Ring:	Silicon Carbide
d. Rotating Ring:	Silicon Carbide
e. O-rings:	EPDM

The Silicon Carbide shall be imbedded with graphite.

5. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, motor couplings, motor and seal cover. The entire cartridge shaft seal shall be removable as a one piece component. Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

2.3 VARIABLE FREQUENCY DRIVES (Panel Mount)

A. The VFD shall convert incoming fixed frequency single-phase or three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC induction motors. The VFD shall be a six-pulse input design, and the input voltage rectifier shall employ a full wave diode bridge; VFD's utilizing controlled SCR rectifiers shall not be acceptable. The output waveform shall closely approximate a sine wave. The VFD shall be of a PWM output design utilizing current IGBT inverter technology and voltage vector control of the output PWM waveform.

B. The VFD shall include a full-wave diode bridge rectifier and maintain a displacement power factor of near unity regardless of speed and load.

C. The VFD shall produce an output waveform capable of handling maximum motor cable distances of up to 1,000 ft. (unshielded) without tripping or derating.

D. The VFD shall utilize an output voltage-vector switching algorithm, or equivalent, in both variable and constant torque modes. VFD's that utilize Sine-Coded PWM or Look-up tables shall not be acceptable.

E. VFD shall automatically boost power factor at lower speeds.

F. The VFD shall be able to provide its full rated output current continuously at 110% of rated current for 60 seconds.

G. An empty pipe fill mode shall be available to fill an empty pipe in a short period of time, and then revert to the PID controller for stable operation.

H. Switching of the input power to the VFD shall be possible without interlocks or damage to the VFD at a minimum interval of 2 minutes.

I. Switching of power on the output side between the VFD and the motor shall be possible with no limitation or damage to the VFD and shall require no additional interlocks.

J. The VFD shall have temperature controlled cooling fans for quiet operation, minimized internal losses, and greatly increased fan life.

K. VFD shall provide full torque to the motor given input voltage fluctuations of up to +10% to -15% of the rated input voltage.

L. The VFD shall provide internal DC link reactors to minimize power line harmonics and to provide near unity power factor. VFD's without a DC link reactor shall provide a 5% impedance line side reactor.

M. VFD to be provided with the following protective features:

1. VFD shall have input surge protection utilizing MOV's, spark gaps, and Zener diodes to withstand surges of 2.3 times line voltage for 1.3 msec.

2. VFD shall include circuitry to detect phase imbalance and phase loss on the input side of the VFD.

3. VFD shall include current sensors on all three-output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.

4. VFD shall auto-derate the output voltage and frequency to the motor in the presence of sustained ambient temperatures higher than the normal operating range, so as not to trip on an inverter temperature fault. The use of this feature shall be user-selectable and a warning will be exported during the event. Function shall reduce switching frequency before reducing motor speed.

5. VFD shall auto-derate the output frequency by limiting the output current before allowing the VFD to trip on overload. Speed can be reduced, but not stopped.

6. The VFD shall have the option of an integral RFI filter. VFD enclosures shall be made of metal to minimize RFI and provide immunity.

N. VFD to be provided with the following interface features:

1. VFD shall provide an alphanumeric backlit display keypad, which may be remotely mounted using standard 9-pin cable. VFD may be operated with keypad disconnected or removed entirely. Keypad may be disconnected during normal operation without the need to stop the motor or disconnect power to the VFD.

2. VFD shall display all faults in plain text; VFD's, which can display only fault codes, are not acceptable.

3. All VFD's shall be of the same series, and shall utilize a common control card and LCP (keypad/display unit) throughout the rating range. The control cards and keypads shall be interchangeable through the entire range of drives used on the project.

4. VFD keypad shall be capable of storing drive parameter values in non-volatile RAM uploaded to it from the VFD, and shall be capable of downloading stored values to the VFD to facilitate programming of multiple drives in similar applications, or as a means of backing up the programmed parameters.

5. 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.

6. A start guide menu with factory preset typical parameters shall be provided on the VFD to facilitate commissioning.

7. VFD shall provide full galvanic isolation with suitable potential separation from the power sources (control, signal, and power circuitry within the drive) to ensure compliance with PELV requirements and to protect PLC's and other connected equipment from power surges and spikes.

8. All inputs and outputs shall be optically isolated. Isolation boards between the VFD and external control devices shall not be required.

9. There shall be three programmable digital inputs for interfacing with the systems external control and safety interlock circuitry. An additional digital input is preprogrammed for start/stop.

10. The VFD shall have two analog signal inputs. One dedicated for sensor input and one for external set point input.

11. One programmable analog output shall be provided for indication of a drive status.

12. The VFD shall provide two user programmable relays with selectable functions. Two form 'C' 230VAC/2A rated dry contact relay outputs shall be provided.

13. The VFD shall store in memory the last 5 faults with time stamp and recorded data.

14. The VFD shall be equipped with a standard RS-485 serial communications port for communication to the multi-pump controller. The bus communication protocol for the VFD shall be the same as the controller protocol.

O. VFD service conditions:

1. Ambient temperature operating range, -10 to 45ºC (14 to 113°F) Continuous; 50 ºC max temperature Intermittent.

2. 0 to 95% relative humidity, non-condensing.

3. Elevation to 1000 meters (3,300 feet) without derating.

4. VFD's shall be rated for line voltage of 525 to 690VAC, 380 to 480VAC, or 200 to 240VAC; with +10% to -15% variations. Line frequency variation of ± 2% shall be acceptable.

5. No side clearance shall be required for cooling of the units.

2.4 FIXED SPEED MOTORS

A. Fixed Speed Motors are to be provided with the following basic features:

1. Designed for continuous duty operation, NEMA design B with a 1.15 service factor.

2. Totally Enclosed Fan Cooled or Open Drip Proof with Class F insulation.

3. Nameplate shall have, as a minimum, all information as described in NEMA Standard MG 1-20.40.1.

4. Motors shall have a NEMA C-Flange for vertical mounting.

5. Drive end bearings shall be adequately sized so that the minimum L10 bearing life is 17,500 hours at the minimum allowable continuous flow rate for the pump.

2.5 PUMP SYSTEM CONTROLLER

A. The pump system controller shall be a standard product developed and supported by the pump manufacturer.

B. The controller shall be microprocessor based capable of having software changes and updates via personal computer (notebook). The controller user interface shall have a color display with a minimum screen size of 3-1/2" x 4-5/8" for easy viewing of system status parameters and for field programming. The display shall have a back light with contrast adjustment. Password protection of system settings shall be standard.

C. The controller shall provide internal galvanic isolation to all digital and analog inputs as well as all fieldbus connections.

D. The controller shall have the ability to be connected to a battery to maintain power on controller during periods of loss of supply power.

E. The controller shall have built in data logging capability. Logged vales shall be graphically displayed on the controller and able to be exported. A minimum of 7200 samples per logged value with the following parameters available for logging:

   - Estimated flow-rate
   - Speed of pumps
   - Inlet pressure
   - Process Value (usually discharge pressure of differential pressure depending on application)
   - Power consumption
   - Controlling parameter (process value)

F. The controller shall display the following as status readings from a single display on the controller (this display shall be the default):

   - Current value of the control parameter, (typically discharge pressure)
   - Most recent existing alarm (if any)
   - System status with current operating mode
   - Status of each pump with current operating mode and rotational speed as a percentage (%)
   - Estimated flow-rate, (not requiring flow meter connection)
   - User defined measured or calculated data
   - Electrical connection overview (all digital I/O and analog I/O)

G. The controller shall have as a minimum the following hardware inputs and outputs:

   - Three analog inputs (4-20mA or 0-10VDC)
   - Three digital inputs
   - Two digital outputs
   - Ethernet connection
   - Field Service connection to PC for advanced programming and data logging

H. The controller shall be capable of controlling up to six differential pressure zones within a defined differential pressure band. Multi-sensor control shall optimize setpoints by analyzing the minimum limit of each multisensory.

I. Pump system programming (field adjustable) shall include as a minimum the following:

   - Water shortage protection (analog or digital)
   - Sensor Settings (Suction, Discharge, Differential Pressure analog supply/range)
   - PI Controller (Proportional gain and Integral time) settings
   - High system pressure indication and shut-down
   - Low system pressure indication and shut-down
   - Low suction pressure/level shutdown (via digital contact)
   - Low suction pressure/level warning (via analog signal)
   - Low suction pressure/level shutdown (via analog signal)
   - Flow meter settings (if used, analog signal)

J. The controller shall be able to control using up to six DP sensors (zones). The zones shall have priority control setting and minimum and maximum setpoint limits for each DP sensor or zone.

K. The system controller shall be able to detect motor turning opposite direction and give check valve failure notification.

L. The system controller shall be able to input pulse readings from digital pulse meter and log/display accumulated flow.

M. The system controller shall be able to control off subtraction of two pressure or temperature sensors for differential pressure or differential temperature control.

N. The system controller shall be able to accept up to seven programmable set-points via a digital input, (additional input/output module may be required).

O. The controller shall have advanced water shortage protection. When analog sensors (level or pressure) are used for water shortage protection, there shall be two indication levels. One level is for warning indication only (indication that the water level/pressure is getting lower than expected levels) and the other level is for complete system shut-down (water or level is so low that pump damage can occur). System restart after shut-down shall be manual or automatic (user selectable).

P. The system pressure set-point shall be capable of being automatically adjusted by using an external set-point influence. The set-point influence function enables the user to adjust the control parameter (typically pressure) by measuring an additional parameter. (Example: Lower the system pressure set-point based on a flow measurement to compensate for lower friction losses at lower flow rates).

Q. The controller shall be capable of receiving a remote analog set-point (4-20mA or 0-10 VDC) as well as a remote system on/off (digital) signal.

R. The controller shall be able to adjust the ramp time of a change in set point on both an increase or decrease change in set point.

S. The pump system controller shall store up to 24 warning and alarms in memory. The time, date and duration of each alarm shall be recorded. A potential-free relay shall be provided for alarm notification to the building management system. The controller shall display the following alarm conditions:

High System Pressure	Low system pressure
Low suction pressure (warning and alarm)	Individual pump failure
VFD trip/failure	Loss of sensor signal (4-20 mA)
Loss of remote set-point signal (4-20mA)	External Fault

T. The pump system controller shall be mounted in a UL Type 3R rated enclosure. A self-certified NEMA enclosure rating shall not be considered equal. The entire control panel shall be UL 508 listed as an assembly. The control panel shall include a main disconnect, circuit breakers for each pump and the control circuit and control relays for alarm functions.

Control panel options shall include, but not be limited to:

Pump Run Lights
System Fault Light
80 dB System Fault Audible Alarm
Emergency/Normal Operation Switches
Service Disconnect Switches (accessible from side of panel)
Surge Arrestor
100kA SCCR panel rating

U. The controller shall be capable of receiving a redundant sensor input to function as a backup to the primary sensor (typically discharge pressure).

V. Upon loss of signal from remote sensor the controller shall be capable of reverting control to local mounted sensor with new corresponding setpoint.

W. The controller shall have a pump "Test Run" feature such that pumps are switched on during periods of inactivity (system is switched to the "off" position but with electricity supply still connected). The inoperative pumps shall be switched on for a period of two to three (3-4) seconds every 24 hours, 48 hours or once per week and at specific time of day (user selectable).

X. The controller shall be capable of changing the number of pumps available to operate or have the ability limit the maximum power consumption by activation of a digital input for purposes of limited generator supplied power.

Y. The controller shall be capable of displaying instantaneous power consumption (Watts or kilowatts) and cumulative energy consumption (kilowatt-hours).

Z. The controller shall be capable of displaying instantaneous specific energy use (kW/gpm), (optional flow meter must be connected).

AA. The actual pump performance curves (5th order polynomial) shall be loaded (software) into the pump system controller. Pump curve data shall be used for the following:

   a. Display and data logging of calculated flow rate (not requiring flow measurement)
   b. Proportional pressure control
   c. Pump outside of duty range protection
   d. Pump cascade control based on pump efficiency

BB. The controller shall be capable of displaying an estimated flow-rate on the default status screen.

CC. The controller shall have proportional pressure control to compensate for pipe friction loss by decreasing pressure set-point at lower flow-rates and increasing pressure set-point at higher flow-rates by using actual flow rate or calculated flow rate. Proportional pressure control that uses pump speed or power consumption only shall not be considered equal to proportional pressure control that uses actual or calculated flow rate.

DD. The controller shall have the ability to communicate common field-bus protocols, (BACnet, Modbus, Profibus, and LON), via optional communication expansion card installed inside controller.

EE. The controller shall have Ethernet connection with a built-in server allowing for connection to a network with read/write access to controller via web browser and internet.

FF. The controller shall have a programmable Service Contact Field that can be populated with service contact information including: contact name, address, phone number(s) and website.

2.4   SEQUENCE OF OPERATION

2.5   The system controller shall operate equal capacity variable speed pumps to maintain a constant differential pressure (system set-point from remote DP sensor) or proportional pressure differential pressure setpoint (system setpoint from local mounted sensor(s)), depending on the application. The system controller shall receive an analog signal [4-20mA] from the factory installed pressure transducer on the discharge and suction manifolds, indicating the actual system pressure and inlet pressure. The controller shall be capable of controlling off the subtraction of discharge minus suction transducers for differential pressure across the manifolds.

Standard Cascade Control (Pumping Efficiency Based):
The pump system controller shall adjust pump speed as necessary to maintain system set-point pressure as flow demand increases. Utilizing the pump curve information (5th order polynomial), the pump system controller shall stage on additional pumps when pump hydraulic efficiency will be higher with additional pumps in operation. Exception: When the flow and head are outside the operating pump(s) allowable operating range the controller shall switch on an additional pump

thus distributing flow and allowing all pump(s) to operate in allowable operating range. When the system pressure is equal to the system set-point, all pumps in operation shall reach equal operating speeds. The pump system controller shall have field adjustable Proportional Gain and Integral time (PI) settings for system optimization.

Optional Cascade Control (Pump Start Speed Based):
As flow demand increases the pump speed shall be increased to maintain the system set-point pressure. When the operating pump(s) reach 96% of full speed (adjustable), an additional pump will be started and will increase speed until the system set-point is achieved. When the system pressure is equal to the system set-point all pumps in operation shall reach equal operating speeds. The pump system controller shall have field adjustable Proportional Gain and Integral time (PI) settings for system optimization.

2.6   The system controller shall be capable of switching pumps on and off to satisfy system demand without the use of flow switches, motor current monitors or temperature measuring devices.

2.7   All pumps in the system shall alternate automatically based on demand, time and fault. If flow demand is continuous (no flow shut-down does not occur), the system controller shall have the capability to alternate the pumps every 24 hours, every 48 hours or once per week. The interval and actual time of the pump change-over shall be field adjustable.

2.6   SYSTEM CONSTRUCTION

A. Suction and discharge manifold construction shall be in way that ensures minimal pressure drops, minimize potential for corrosion, and prevents bacteria growth at intersection of piping into the manifold. Manifold construction that includes sharp edge transitions or interconnecting piping protruding into manifold is not acceptable. Manifold construction shall be such that water stagnation cannot exist in manifold during operation to prevent bacteria growth inside manifold.

B. The suction and discharge manifolds material shall be 316 stainless steel. Manifold connection sizes shall be as follows:

        3 inch and smaller: Male NPT threaded
        4 inch through 8 inch: ANSI Class 150 rotating flanges
        10 inch and larger: ANSI Class 150 flanges

C. Pump Isolation valves shall be provided on the suction and discharge of each pump. Isolation valve sizes 2 inch and smaller shall be nickel plated brass full port ball valves. Isolation valve sizes 3 inch and larger shall be a full lug style butterfly valve. The valve disk shall be of stainless steel. The valve seat material shall be EPDM and the body shall be cast iron, coated internally and externally with fusion-bonded epoxy.

D. A spring-loaded non-slam type check valve shall be installed on the discharge of each pump. The valve shall be a wafer style type fitted between two flanges. The head loss through the check valve shall not exceed 5 psi at the pump design capacity. Check valves 1-1/2" and smaller shall have a POM composite body and poppet, a stainless steel spring with EPDM or NBR seats. Check valves 2" and larger shall have a body material of stainless steel or epoxy coated iron (fusion bonded) with an EPDM or NBR resilient seat. Spring material shall be stainless steel. Disk shall be of stainless steel or leadless bronze.

E. For systems that require a diaphragm tank, a connection of no smaller than ¾" shall be provided on the discharge manifold.

F. A pressure transducer shall be factory installed on the discharge manifold (or field installed as specified on plans). Systems with positive inlet gauge pressure shall have a factory installed pressure transducer on the suction manifold for water shortage protection. Pressure transducers shall be made of 316 stainless steel. Transducer accuracy shall be +/- 1.0% full scale with

hysteresis and repeatability of no greater than 0.1% full scale. The output signal shall be 4-20 mA with a supply voltage range of 9-32 VDC.

G. A bourdon tube pressure gauge, 2.5 inch diameter, shall be placed on the suction and discharge manifolds. The gauge shall be liquid filled and have copper alloy internal parts in a stainless steel case. Gauge accuracy shall be 2/1/2 %. The gauge shall be capable of a pressure of 30% above its maximum span without requiring recalibration.

H. Systems with a flooded suction inlet or suction lift configuration shall have a factory installed water shortage protection device on the suction manifold.

I. The base frame shall be constructed of corrosion resistant 304 stainless steel. Rubber vibration dampers shall be fitted between each pumps and baseframe to minimize vibration.

J. Depending on the system size and configuration, the control panel shall be mounted in one of the following ways:

> On a 304 stainless steel fabricated control cabinet stand attached to the system skid.
> On a 304 stainless steel fabricated skid, separate from the main system skid
> On its own base (floor mounted with plinth)

2.8   TESTING

A. The entire pump station shall be factory tested for functionality. Functionality testing shall include the following parameters: Dry Run Protection, Minimum Pressure and Maximum Pressure alarms (where applicable), Setpoint Operation, and Motor Rotation.

B. The system shall undergo a factory hydrostatic test at the end of the production cycle. The system shall be filled with water and pressurized to 1.5 times the nameplate maximum pressure. Systems with 150# flange connections shall be tested at 350 psig, and systems with 300# flange connections shall be tested at 450 psig. The pressure shall be maintained for a minimum of 15 minutes with no leakage (slight leakage around pump(s) mechanical seal is acceptable) prior to shipment.

2.8   WARRANTY

A. The warranty period shall be a non-prorated period of 24 months from date of installation, not to exceed 30 months from date of manufacture.