Hydro MPC-E CRE (Integrated VFD/PM Motor) HVAC 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:

ANSI – American National Standards Institute	Hydraulic Institute
ASTM – American Society for Testing and Materials	NEC – National Electrical Code
IEEE – Institute of Electrical and Electronics Engineers	ISO – International Standards Organization
NEMA – National Electrical Manufacturers Association	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 a constant or variable differential 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.

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 (CR3 to CR20) 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: Graphite embedded Silicon Carbide
    d. Rotating Ring: Graphite embedded Silicon Carbide
    e. O-rings: EPDM

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.

6. 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 (CR32 to CR155) In-line Vertical Multi-Stage Pumps (Nominal flows from 130 to 1070 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 70-50-05)
    b. Shaft couplings, flange rings: Ductile Iron (ASTM 70-50-05)
    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

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: Graphite embedded Silicon Carbide
    d. Rotating Ring: Graphite embedded Silicon Carbide
    e. O-rings: EPDM

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.

6. 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 INTEGRATED VARIABLE FREQUENCY DRIVE MOTORS

A. Efficiency: The motors shall be of permanent magnet design meeting IE5 efficiency levels where the combined motor and VFD efficiency exceed NEMA Premium Efficiency standards.

B. Bearing Current Mitigation: Motors shall use WSB (Winding Set Back) and/or CHS (Coil Head Shield) designs that reduce the Bearing Voltage Ratio (BVR) far enough to eliminate damaging bearing currents. Shaft grounding rings/brushes or common mode filters shall not be required.

C. Motor Enclosure/Cooling: The motor shall be Totally Enclosed Fan Cooled (TEFC) with a standard NEMA C-Face with Class F insulation and a temperature rise class no higher than Class B. The cooling design of the motor and VFD shall be such that a Class B motor temperature rise is not exceeded at full rated load and speed at a minimum switching frequency of 9.0 kHz.

D. The power and control electronics shall be housed in a UL Type 3 enclosure and the combined motor/VFD rating shall be IP55 (protection against dust and nozzle directed water from any direction).

E. The VFD shall be of the PWM (Pulse Width Modulation) design using IGBT (Insulated Gate Bipolar Transistor) technology.

F. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of motor. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor current suitable for centrifugal pump control and to eliminate the need for motor de-rating.

G. The VFD shall automatically reduce the switching frequency and/or the output voltage and frequency to the motor during periods of sustained ambient temperatures that are higher than the normal operating range. The switching frequency shall be reduced before motor speed is reduced.

H. An integral RFI filter shall be standard in the VFD.

I. The VFD shall have a minimum of two skip frequency bands which can be field adjustable.

J. The VFD shall have internal solid-state overload protection designed to trip within the range of 105-110% of rated current.

K. The integrated VFD motor shall include protection against input transients, phase imbalance, loss of AC line phase, over-voltage, under-voltage, VFD over-temperature, and motor over-temperature. Three-phase integrated VFD motors shall be capable of providing full output voltage and frequency with a voltage imbalance of up to 10%.

L. The integrated VFD motor shall have, as a minimum, the following input/output capabilities:

1. Speed Reference Signal: 0-10 VDC, 4-20mA
2. Digital remote on/off
3. Fault Signal Relay (NC or NO)
4. Fieldbus communication port (RS485)

M. Motor drive end bearings shall be adequately sized so that the minimum L10 bearing life is 20,000 hours at the minimum allowable continuous flow rate for the pump at full rated speed.

2.4 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. Galvanic Isolation: The controller shall provide internal galvanic isolation to all digital and analog inputs as well as all fieldbus connections.

D. Backup Battery: The controller shall have the ability to be connected to a backup battery to supply power to the controller during periods of loss of supply power.

E. Home Status Screen: 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 differential 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, (or actual flow if flow sensor is used)
- One user defined measured parameter (i.e. power consumption)

F. Inputs/Outputs: 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 (built-in web server)
- Field Service connection to PC for advanced programming, software and/or firmware upgrades and data logging

G. Pump system programming: As a minimum, the following parameters shall be available and/or field adjustable:

- Sensor Settings: Suction, Discharge, Differential Pressure [analog supply/range]
- PI Controller: Proportional gain (Kp) and Integral time (Ti)
- Low suction: Pressure/level shutdown via digital contact
- Limit Exceeding function: For low system, low suction warnings and shut down [via analog input]
- Flow meter settings (if used, analog signal)

H. Pump Curve Data: 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
   b. Variable pressure control (quadratic or proportional)
   c. Pump outside of duty range protection
   d. Sequence pumps based on efficiency

I. Variable Pressure Control: The controller shall have variable pressure control to compensate for pipe friction loss by decreasing the pressure set-point at lower flow-rates and increasing the pressure set-point at higher flow-rates by using the actual flow rate or calculated flow rate. Variable pressure control that uses power consumption and speed only shall not be considered equal to variable pressure control that uses actual differential pressure measurement along with pump power and speed.

J. Multi-Sensor: The controller shall be able to control using up to six differential pressure (DP) sensors (zones). Each zone shall have a programmable maximum and minimum DP range. The controller shall

be capable of an energy optimal mode where pump speed/energy shall be reduced until any of the zones reach the minimum DP setting.

K. <u>Check Valve Failure Detection</u> (Systems with integrated VFD motors): The system controller shall be able to detect motors turning in the opposite direction and give check valve failure notification.

    1. For minor leaks the pump shall start with a warning indicated
    2. For major leaks the pump shall remain off to prevent damage with an alarm indication

L. <u>Pulse flow meter</u>: The system controller shall be able to receive pulse readings from a digital pulse meter and log/display accumulated flow.

M. <u>DP Subtraction</u>: The system controller shall be able to control off subtraction of two pressure or temperature sensors for differential pressure or differential temperature control.

N. <u>Programmable Setpoints</u>: 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. <u>Setpoint Influence</u>: 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 differential pressure) by measuring an additional parameter. (Example: Lower the system differential pressure set-point based on a flow or outdoor temperature measurement).

P. <u>Remote Control</u>: 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.

Q. <u>Setpoint Ramp:</u> The controller shall be able to adjust the ramp time of a change in set point (increase and decrease).

R. <u>Warnings and Alarms:</u> The pump system controller shall store up to 24 warnings 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:

Individual pump failure	Check valve failure
VFD trip/failure	Loss of sensor signal (4-20 mA)
Loss of remote set-point signal (4-20mA)	External Fault
Pump outside of duty range	Limit 1 and 2 exceeded*

*The controller shall be capable of monitoring two analog signals (i.e. suction pressure and discharge pressure) for additional pump or system protection.

S. <u>Built-in data log</u>: The controller shall have built-in data logging capability. Logged values shall be graphically displayed on the controller and shall be downloadable to a notebook/pc as a delimited text file. A minimum of 7200 samples per logged value shall be available for the following parameters:

- Estimated flow-rate (or actual flow if flow sensor is connected)
- Speed of pumps
- Process Value/sensor feedback (usually differential pressure)
- Power consumption
- Controlling parameter (setpoint)
- Inlet pressure (when remote differential pressure is the primary sensor)

T. <u>Redundant Primary Sensor</u>: The controller shall be capable of receiving a redundant sensor input to function as a backup to the primary sensor.

U. <u>Secondary Sensor</u>: Upon loss of signal from the remote sensor, the controller shall be capable of reverting control to the pump system mounted sensors with a programmable setpoint. The pumps shall

maintain a constant, proportional or quadratic pressure across the system until the remote setpoint signal is restored.

V. Pump Test: 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 three to four seconds every 24 hours, 48 hours or once per week and at a programmable time of day.

W. Reduced Operation: During backup generator operation, the controller shall be capable of reducing the power consumed by the pump system by either limiting the number of pumps in operation or by limiting the amount of power consumption (kW). The controller shall receive a digital input indicating backup generator operation.

X. Power and Energy Consumption: The controller shall be capable of displaying instantaneous power consumption (Watts or kilowatts) and cumulative energy consumption (kilowatt-hours).

Y. Specific Energy: When a flow sensor is connected, the controller shall be capable of displaying instantaneous specific energy in Watt-hours per gallon (Wh/gal) or Watt-hours per 1,000 gallons (Wh/kgal).

Z. Built-in Ethernet: The controller shall have an Ethernet connection with a built-in web server allowing for connection to a building computer network with read/write access to the controller via a web browser.

AA. Service Contact Information: 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.

2.5   CONTROL PANEL

SCCR: The complete control panel assembly shall have a Short Circuit Current Rating of 100 kA

BMS Integration: Standard shall be BACnet MS/TP
*Other protocols available: BACnet IP, Ethernet IP, Modbus RTU, Modbus TCP, LON

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 UL Type 3R 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. The control panel shall include the following:

   80 dB System Fault Audible Alarm with push button to silence
   Emergency/Normal Operation Switches (Control bypass)
   Individual Service Disconnect Switches (accessible outside of panel)
   Pump Run Lights
   System Fault Light
   Surge Arrestor

2.6   SEQUENCE OF OPERATION

A. The system controller shall operate equal capacity variable speed pumps to maintain a constant differential pressure (sensor feedback from remote DP sensor) or variable differential pressure setpoint [sensor feedback from local mounted sensor(s)]. The system controller shall receive an analog signal [4-20mA] from the factory installed pressure transducers 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 pressure 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 changes. Utilizing the pump curve information (5th order polynomial) combined with suction and discharge pressure measurements, the pump system controller shall stage on additional pumps when pump hydraulic efficiency is determined to be higher with additional pumps in operation. Exception: When the flow and head are outside the operating pumps allowable operating range, the controller shall switch on an additional pump, distributing flow and allowing all pumps to operate within their allowable operating range. When the system pressure is equal to the system set-point, all pumps in operation shall reach equal operating speeds.

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.

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

C. 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, and minimizes potential for corrosion. Manifold construction that includes sharp edge transitions or interconnecting piping protruding into the manifold is not acceptable.

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. Isolation Valves: 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. Check Valves: 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. Pressure Transducers: Pressure transducers shall be factory installed on the suction and discharge manifolds. 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.

F. Pressure Gauges: 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.

G. <u>Base Frame</u>: The base frame shall be constructed of corrosion resistant 304 stainless steel for systems with multistage pumps with 4" connections and smaller (CR3 to CR64). For multistage pumps with 6" or larger connections (CR95 to CR155), the base frame shall be constructed of ASTM A36 structural carbon steel, powder coated white aluminum RAL9006.

H. <u>Control Panel Mounting</u>: 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 tester used for testing the pump system shall be constructed and calibrated according to the requirements of hydraulic test standard ISO 9906.

B. The entire pump station shall as a minimum be factory tested for functionality and documented results of functionality test supplied with pump station.

   <u>Functionality testing shall include the following parameters:</u>

   1. Complete System Hydrostatic Test – 1.5 times the nameplate maximum pressure
   2. Water Shortage Test
   3. Two-Point Setpoint Performance Test.

C. Water used for testing shall be treated with three different filtration systems to ensure only clean water is used for testing pump station.
   1. 25 micron mechanical filter – removes solid parts from water
   2. Activated carbon filter – keeps water clear and eliminates odor
   3. Ultraviolet light system – kills all bacteria growth

D. Optional performance testing shall include: (Select one)
   1. 10-Point Verified Performance Test
   2. Witnessed Verified Performance Test

2.9   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.