



SPECIFICATION FOR SMART™ RUNAROUND GLYCOL AIR-TO-AIR ENERGY RECOVERY SYSTEM

SECTION – RUN AROUND AIR-TO-AIR ENERGY RECOVERY SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes requirements for a pre-packaged and skidded heat recovery system. The system assembly shall include but not be limited to the following major components.

1. One (1) to Four (4) Centrifugal Pumps
2. One (1) Air and Dirt Separator
3. One (1) Expansion Tank
4. Optional One (1) Glycol Feed Unit
5. Optional Heat Exchanger Package
6. All Heat Recovery Coils in the Supply and Exhaust Airstreams
7. Required controls (At the Skid and at the supply/exhaust airstreams)

B. The entire energy recovery system shall be supplied by the same manufacturer. The same manufacturer shall perform the system design, manufacture the coils, and furnish the hydronic pump skid and controls package.

C. All equipment, components, and accessories (except coils and associated components) shall be installed within one or more rigid skid modules and be fully supported throughout. Equipment within the skid boundary shall be fully accessible to permit all standard preventative maintenance (PM) activities and facilitate equipment removals and replacements.

D. General arrangements of each skid are indicated in the drawings. The skid shall be fabricated within the skid boundary limits indicated. If boundary limits cannot be maintained, the vendor shall submit to construction manager and engineer of record reasons for expanding the skid and proposed new boundary limits for approval before proceeding. The new limits shall be coordinated with existing conditions and new work prior to submission for approval.

E. All items that fall under the scope of the run around air-to-air energy recovery system manufacturer/supplier shall follow the specifications detailed in this section to the exclusion of all other sections under this or all other specifications. This exclusion applies regardless of how directly or indirectly other sections are associated with this system.



F. All items that fall under the scope of the run around air-to-air energy recovery system manufacturer/supplier not detailed in this section of the specification shall default to the standard manufacturing practices of the system manufacturer/supplier and not to any other section of this or other specification(s).

1.2 ACCEPTABLE SYSTEM MANUFACTURER/SUPPLIER

A. Heat Pipe Technology

1.3 RELATED DOCUMENTS

A. Designs and components installed on the pump skid shall be defined in the vendor's submittal. Approval of the vendor's submittal shall imply design in the submittal is accepted as submitted and supersede and override the requirements of this and/or any other specification or communication.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, vendor shall include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For air-to-air energy recovery equipment,

1. Include plans, elevations, sections, and mounting details.

a) details of pump skid and coils supplied by vendor

b) details of connecting pipework between pump skid and coils supplied by others

2. Include details of equipment assemblies. Indicate dimensions, weights, required clearances, method of field assembly, components, and location and size of each field connection.

3. Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.6 COORDINATION

A. It shall be the responsibility of the installing contractor to coordinate sizes and location of equipment prior to system approval and build.

1.7 DELIVERY, STORAGE, AND HANDLING (BY OTHERS)

A. Deliver and store products in a clean, dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.



- C. Handle products carefully to prevent damage, breakage, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 - 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 - 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
 - 3. Replace installed products damaged during construction.

1.8 WARRANTY

- A. Warranty: System manufacturer shall submit a warranty document when providing submittals for a project.
- B. Warranty shall cover a minimum of eighteen (18) months after shipping from manufacturer, or twelve (12) months after startup (whichever occurs first). This warranty shall cover all manufacturer-supplied parts and components.
- C. Other statements of warranty including limitations on liability shall be included in manufacturer-supplied warranty statement and shall be in full force upon shipment of the unit.



PART 2 - PRODUCTS

2.1 COMPLETE FACTORY FABRICATED PUMPED GLYCOL ENERGY RECOVERY PACKAGE

A. AIR-TO-AIR ENERGY RECOVERY SYSTEM - GENERAL

1. A run-around pumped glycol system as detailed in plans will provide energy recovery for this unit, with supply and exhaust coils mounted in the unit, a pre-assembled hydronic unit and miscellaneous other components in order to make the system fully operable, having efficiencies as listed in the attached performance schematics and coil schedules.
2. A pre-packaged run-around pumped glycol air-to-air energy recovery system will be provided by Heat Pipe Technology Inc. This system will include supply and exhaust coils per schedule (details in energy recovery coils section below) and a pre-assembled pumping system. Components supplied by others comprise the interconnecting piping between the heat recovery coils and pumping system, control and power wiring, and the insulation on the whole system. The system shall be designed as a parallel loop with air handler supply and exhaust heat recovery coils interconnected and one hydronic system and control system for the loop. The system shall have variable speed pumping and variable flow to the supply and exhaust coils. The system fluid shall be a **[0-50% propylene/ethylene]** glycol and water mix by volume.
3. The runaround glycol system supplier shall have a minimum of 20 years of experience designing, manufacturing, and installing air-to-air energy recovery systems. Heat exchanger coils must be manufactured and assembled at the system supplier's own facility.
4. System performance capacities, entering and leaving dry and wet bulb temperatures, and face velocity shall be as specified.
5. Scheduled effectiveness or heat recovery shall be met at a minimum and total pressure drop shall not be exceeded.
6. The runaround glycol system shall have a warranty covering a minimum of eighteen (18) months after shipping from manufacturer or twelve (12) months after startup (whichever occurs first). The warranty shall cover the system (heat exchange coils and hydronic components on the pump skid).
7. Hydronic Module (pumping package) will include the following components preassembled and pre-mounted to structural equipment skid. The skid module will be provided, comprising one to four pumps, VFD(s), control panel, control valves, air separator, expansion tank, and pressure relief device(s).
8. [OPTIONAL] Plate heat exchangers, when required for the purpose of achieving the supply air set point, shall be furnished as part of this system.



9. Sensors and control valves will be rated for NEMA 2 indoor use.

10. System Controller

- (a) The Control Panel will measure four water temperatures and the leaving air temperature on each supply and exhaust airstream and control pump speed and valve positions to:
 - (1) Individually maintain a supply air temperature set point in each supply airstream
 - (2) Prevent frosting, by maintaining a minimum exhaust air temperature (adjustable – typically 36°F)
 - (3) Switch off power to the pump when there is no need for energy recovery (e.g. economizer).
- (b) The controller can be connected to the BAS via BACnet or MODBUS, using MSTP or Ethernet, through which the BAS can view system running status, temperatures, pump status, valve positions and alarm notifications. The BAS can change set points remotely and instruct the system to run or not. The system will also run as a standalone system (without the need for BAS) and can be enabled/disabled remotely via a dry contact input.
- (c) The controller will check static gauge pressure on the inlet to the pump and will only operate when a minimum water pressure is present, to avoid accidental dry running. The controller will monitor the differential pressure head across the pump(s) to confirm they are operating properly.
- (d) The system provides a dry contact output to indicate a general alarm – to alert the maintenance technician to review the system.
- (e) The controller provides, on the touchscreen and through the BAS, an indication to whether the system is in Heating Mode, Cooling Mode, or Economizer.
- (f) The Control Panel will monitor the hours each pump runs and periodically switch which pumps lead and lag. If one pump fails, the system will automatically switch over to a redundant pump if one is available.
- (g) A 10" color touch screen display will present key system performance information so, when at the pump skid, the maintenance technician can: see system performance; change set points; check alarms; and manage pump control. The menu will be intuitive, so minimal training is required to understand the system. The front of the display will be rated IP65 (dust tight and protected against water jets from any angle).
- (h) Sensors, control valves and enclosure shall be rated for indoor use.



- (i) The controller shall communicate with the VFD(s) so it can relay VFD operational data to the BAS. These data include run status, voltage, current, power, hand/off status, and alarms. This allows for a single communication point for the BAS.

B1. AIR-TO-AIR ENERGY RECOVERY SYSTEM – TWO AIRSTREAMS

1. Two airstreams refers to controls where there are one supply airstream and one exhaust airstream. All the flow for the one supply airstream runs through the skid, so there is no need for a local valve control at either supply or exhaust airstreams. There is no need for balancing valves between airstreams.

2. Performance optimization and control will be achieved through varying pump speed and varying valve positions. Two separate control valves, an inline valve and a bypass valve, shall be used so that the system has the flexibility to work optimally in winter and summer conditions. One three-way valve will not be accepted.

(a) The control panel will have a Hand-Off-Auto selection, where:

- (1) Hand – the user can override other inputs locally and run the system at an adjustable output.
- (2) Off – the user can deactivate the system locally.
- (3) Auto – a remote enable/disable dry contact input (from a BAS) can tell the system when to run in Auto and when not to. When enabled, it will run at the appropriate pump speed and valve position as defined by the sequence of operation.

3. The system will also run as a standalone system (without the need for BAS) and can be enabled/disabled remotely via a single dry contact input. The system provides three dry contact outputs to indicate:

- (a) A general alarm – to alert the maintenance technician to review the system
- (b) Economizer mode active – in case a bypass damper is in use (supplied by others) to minimize airside pressure drop losses
- (b) Frost control active – in case a preheater is in use (supplied by others).

B2. AIR-TO-AIR ENERGY RECOVERY SYSTEM – MULTIPLE AIRSTREAMS

1. Multiple airstreams refers to controls where there is more than one supply airstream, or more than one exhaust airstream, or both.

2. Each supply and exhaust airstream will use Pressure Independent Control (PIC) valves to control the fluid flow rate through the coil(s). Where multiple banks of coils are installed in a single airstream, one PIC valve per bank will be provided. The PIC valves also act as flow limiting devices and negate the need for balancing in the field.



3. Performance optimization and control will be achieved by varying PIC valve positions to control the rate of fluid flow through each airstream independently. The skid will maintain pressure to the PIC valves by varying pump speed.
4. Two separate control valves, a supply bypass valve and an exhaust bypass valve, shall be used so that the system has the flexibility to work optimally in winter and summer conditions.
 - (a) The control panel will have an Off-Auto selection and the ability to override valve positions in any of the supply or exhaust airstreams (Hand), where:
 - (1) Hand – the user can override the commanded valve position locally, through the touchscreen, or using the BAS. Since valve position determines flow requirements, the skid responds automatically to supply the appropriate flow. One or more airstreams can run with an override whilst one or more different airstreams run in auto.
 - (2) Off – the user can deactivate the system locally.
 - (3) Auto – a remote enable/disable dry contact input (from a BAS) can tell the system when to run in Auto and when not to. When enabled, it will run at the appropriate pump speed and valve position as defined by the sequence of operation. The enable/disable can also be commanded through the BAS communications interface.
 - (b) The controller will know which airstreams to activate, using either commands through the BAS or using the dry contact inputs. Each supply and exhaust airstream has a unique input, so they can be activated and deactivated individually. For example, a supply airstream may be activated when the fans in that airstream operate and deactivated when they stop.
 - (c) The controller provides, on the touchscreen and through the BAS, a range of alerts, which prompt the technician for attention but keeps the system running:
 - (1) Temperature sensor failure on each airstream
 - (2) Locked points or points being overridden
 - (3) High static pressures
 - (4) Water/glycol temperature sensor failures (3)
 - (5) Pump VFD is in Hand mode
 - (6) If an optional glycol makeup system is included, the controller indicates when the makeup is active, and the tank is low.
 - (7) Individual pump failure



(d) The controller provides, on the touchscreen and through the BAS, a range of alarms, which prompt the technician for attention and stop the system:

(1) Water/glycol temperature sensor failures (1)

(2) Low pump suction pressure

(3) All pumps fail

(4) Significant temperature or pressure imbalance between supply and exhaust branches.

B3. PRECOOL - REHEAT ENERGY RECOVERY SYSTEM

1. Precool-Reheat refers to a system comprising:

i) A set of coils in each exhaust airstream with air temperature sensors upstream and downstream

ii) Two sets of coils in each supply airstream – one before the cooling coil and one after with each set of coils having air temperature sensors upstream and downstream.

iii) Pump skid comprising pumps, hydronic components, control valves, and pressure & temperature sensors.

iv) A sensor skid for each supply airstream, which controls the amount of water-glycol (fluid) supplied to each coil set. This sensor skid(s) include control valves, pressure sensors and fluid temperature sensor.

2. This system is available for both two and multiple airstream applications.

3. The control system responds to the air temperatures entering and leaving the coils, to control in either heating mode or one of two cooling modes.

4. Performance optimization and control is achieved using three-way valves which modulate fluid flow through both energy recovery coils in each supply air handling unit.

5. Each sensor skid includes Pressure Independent Control (PIC) valves. They act both as flow limiting devices and allow individual air handling units to be made inactive or serve as backup units.

6. Pump skid functionality heretofore described for either two airstream or multiple airstream applications apply to the precool-reheat energy recovery system as well:

(a) The control panel will have an Off-Auto selection and the ability to override valve positions in any of the supply or exhaust airstreams (Hand), where:



(1) Hand – the user can override the commanded valve position locally, through the touchscreen, or using the BAS. Since valve position determines flow requirements, the skid responds automatically to supply the appropriate flow. One or more airstreams can run with an override whilst one or more different airstreams run in auto.

(2) Off – the user can deactivate the system locally.

(3) Auto – a remote enable/disable dry contact input (from a BAS) can tell the system when to run in Auto and when not to. When enabled, it will run at the appropriate pump speed and valve position as defined by the sequence of operation. The enable/disable can also be commanded through the BAS communications interface.

(b) The controller will know which airstreams to activate, using either commands through the BAS or using the dry contact inputs. Each supply and exhaust airstream has a unique input, so they can be activated and deactivated individually. For example, a supply airstream may be activated when the fans in that airstream operate and deactivated when they stop.

(c) The controller provides, on the touchscreen and through the BAS, a range of alerts, which prompt the technician for attention but keeps the system running:

(1) Temperature sensor failure on each airstream

(2) Locked points or points being overridden

(3) High static pressures

(4) Water/glycol temperature sensor failures (3)

(5) Pump VFD is in Hand mode

(6) If an optional glycol makeup system is included, the controller indicates when the makeup is active, and the tank is low.

(7) Individual pump failure

(d) The controller provides, on the touchscreen and through the BAS, a range of alarms, which prompt the technician for attention and stop the system:

(1) Water/glycol temperature sensor failures (1)

(2) Low pump suction pressure

(3) All pumps fail



- (4) Significant temperature or pressure imbalance between supply and exhaust branches.

B4. SNOW MELT OPTION

1. Alongside the precool-reheat system, a snow melt option is available. With this option, in winter heating mode, the first upstream energy recovery coil in every air handler is used to preheat the outside air to a temperature setpoint comfortably above freezing.
2. This functionality is only available with the precool-reheat system and with the optional heat injection package selected.
3. This option results in a different controls sequence with the preheat coil setpoint moved to the highest-level priority along with the supply air setpoint.

B5. OPTIONAL HEAT INJECTION PACKAGE

1. Heat injection refers to controls where an external heat source is to be added to the system to boost the system performance so that all desired supply air setpoints are met.
2. This functionality is available for both two and multiple airstream applications as well as the precool-reheat option.
3. When the system controller identifies it cannot maintain one or more supply air setpoint(s) during winter heating, it indicates additional heat is required, by providing an analog output that indicates demand (0-100%).
4. The controller uses the heat demand signal, to control the inline valves to the plate heat exchanger(s) to allow more or less glycol flow through them. Concurrently, this signal is used to both control the bypass valves around the plate heat exchangers and the inline valves on the utility side.
5. The system shall be optimized and controlled such that all airstreams meet their individual supply air setpoint.
6. N+1 heat exchangers are provided for each system. The controller will manage which heat exchanger(s) are operated so, over time, all the heat exchangers will be used for a similar number of hours.
7. Valve control, both inline and bypass, shall also use N+1 redundancy.



B6. OPTIONAL COOLING INJECTION PACKAGE

1. Cooling injection is used when in cooling mode, in-lieu of the cooling coil to cool the outside air and maintain the airstream supply air set point. An external cooling source is used in addition to the exhaust airstream (where applicable) so that all desired supply air setpoints are met.
2. This functionality is available for both two and multiple airstream applications.
3. When the system controller identifies it cannot maintain one or more supply air setpoint(s) during summer cooling, it indicates additional cooling is required, by providing an analog output that indicates demand (0-100%).
4. The controller uses the cooling demand signal, to control the inline valves to the plate heat exchanger(s) to allow more or less glycol flow through them. Concurrently, this signal is used to both control the bypass valves around the plate heat exchangers and the inline valves on the chiller side.
5. The system shall be optimized and controlled such that all airstreams meet their individual supply air setpoint.
6. N+1 heat exchangers are provided for each system. The controller will manage which heat exchanger(s) are operated so, over time, all the heat exchangers will be used for a similar number of hours.
7. Valve control, both inline and bypass, shall also use N+1 redundancy.

C. SUPPLY AND EXHAUST ENERGY RECOVERY COILS

1. Coils shall be constructed of 0.500" diameter copper tubes with 0.024" thick walls and 0.006" thick aluminum fins, spaced at 12 FPI.
2. The coil (s) shall be constructed with internal tube modifications for improved thermal performance.
3. The coil(s) shall have the option of a protective E-Coat, similar to Electrofin or Finkote, or phenolic coat, similar to Heresite.
4. Water velocity in the pipe shall not exceed 3 FPS to minimize parasitic losses in the energy recovery system.
5. Wiring and piping from the skid to the AHU coils shall be provided by the contractor.
6. The AHU manufacturer shall provide condensate drain pans and associated drain piping for the energy recovery coils.



2.2 SOURCE QUALITY CONTROL

- A. AHRI Certification: Heat Exchange coils will be manufactured by a company that maintains AHRI 1060 (Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment) certification on the energy recovery products that fall within the scope of the standard.
- B. Manufacturer shall provide a test report showing that a runaround glycol system manufactured by them has been tested by an independent third party, in accordance with AHRI 1060 (Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment).
- C. Heat Exchange coils shall be UL 207 listed.



PART 3 – PUMP SKID COMPONENTS

3.1 PUMPS

A. BASE MOUNTED, FLEX COUPLED END SUCTION CENTRIFUGAL PUMPS

1. Pumps shall be Taco Model FI or approved equal. The pumps shall be single stage end suction rear pull out design. The bearings and seal shall be serviceable without disturbing the piping connections. The capacities and characteristics shall be as called for in the plans/schedules.
2. Pump casing shall be constructed of ASTM A48 class 30 cast iron. The pump casing/volute shall be rated for 250 psi working pressure for all jobs. The pump flanges shall be matched to suit the working pressure of the piping components on the job, with ANSI Class 125 flanges. The pump casing shall be drilled and tapped for gauge ports on both the suction and discharge connections and for a drain port at the bottom of the casing. The casing shall have an additional tapping on the discharge connection to allow for the installation of a seal flush line. The pump cover shall be drilled and tapped to accommodate a seal flush line which can be connected to the corresponding tapping on the discharge connection, or to an external source to facilitate cooling and flushing of the seal faces.
3. All casings shall be flanged. Threaded casings are not allowed unless extra unions and fittings are provided with that pump to allow servicing.
4. Pump volute shall be foot mounted. Overhung cantilevered designs are not allowable.
5. The pump shall be center line discharge for both positive air venting and allowance for better load distribution.
6. The pump casing inlet shall have an integrally cast anti-rotational vane.
7. The impeller shall be ASTM B584-836/875 bronze ASTM A351/A351M-08 stainless steel and hydraulically balanced. The impeller shall be dynamically balanced to ANSI Grade G6.3 and shall be fitted to the shaft with a key. The impeller shall be cast by the hydraulically efficient lost foam technique to ensure repeatability of high quality.
8. The pump shall incorporate a dry shaft design to prevent the circulating fluid from contacting the shaft. The pump shaft shall be of ASTM A582 Type 416T or ASTM A582 Type 410T stainless steel with field replaceable bronze SAE 660 shaft sleeve. In order to improve serviceability and reduce the cost of ownership the shaft sleeve must be slip on (press on not allowable) and must be easily replaced in the field.
9. The pump shall be fitted with a single mechanical seal, with EPT elastomers and Carbon/Ceramic faces, rated up to 250°F. This seal must be capable of being flushed externally via a tapping in the pump cover adjacent to the seal cavity. Any pump used on an open system shall be furnished with a seal flush line and a Cuno / Kynar / Purocell #900 replaceable cartridge filter or separator with shut-off isolation valve installed in the



seal flushing line. The filter shall have the ability to remove particles down to five microns in size. The entire pump line shall use no more than three different sizes of seals.

10. All pumps to be provided with a fully welded, rigid structural steel base. The base shall include closed ends and top openings to allow for grouting. The base shall include an integral drain pan fabricated from steel with a minimum thickness of 0.1875" and shall contain an integral 3/4" drain connection.

11. The pump bearing frame shall incorporate maintenance free permanently lubricated and sealed bearings with an L10 life of 60,000 hours. Bearing frame shall be equipped with Forsheda seals to protect bearings from moisture and airborne contaminants. The entire line of pumps shall use no more than four different sizes of bearing frames.

12. The pump shall be flexibly coupled to a NEMA standard T frame motor. The coupler shall be suitable for across the line starting as well as variable speed conditions associated with variable frequency drives. The coupling shall be equal to a Woods Dura-Flex coupler. The coupling and shafts shall be covered by a metal guard.

13. To both simplify and reduce the total cost of ownership; the manufacturer shall standardize on no more than three sizes of mechanical seals and four sizes of bearing frames throughout the entire range of the family of pumps. The manufacturer shall not use multiple part numbers for the same part.

B. VERTICAL SPLIT COUPLED PUMPS

1. Pumps shall be Taco Model KS or approved equal. The pumps shall be of vertical inline design. The seal shall be serviceable without disturbing the piping connections. The capacities and characteristics shall be as called for in the plans/schedules.

2. Pump casing shall be constructed of ASTM A48 class 30 cast iron. The pump casing/volute shall be rated for 250 psi working pressure for all jobs. The pump flanges shall be matched to suit the working pressure of the piping components on the job, with ANSI Class 125 flanges. The pump casing shall be drilled and tapped for gauge ports on both the suction and discharge connections and for a drain port at the bottom of the casing. The casing shall have an additional tapping on the discharge connection to allow for the installation of a seal flush line. The pump cover shall be drilled and tapped to accommodate a seal flush line which can be connected to the corresponding tapping on the discharge connection, or to an external source to facilitate cooling and flushing of the seal faces.

3. All casings shall be flanged. Threaded casings are not allowed unless extra unions and fittings are provided with that pump to allow servicing.

4. The pump shall have a factory installed vent/flush line to insure removal of trapped air from the casing and mechanical seal cooling. The vent/flush line shall run from the seal chamber to the pump discharge.



5. The impeller shall be ASTM B584-836/875 bronze or ASTM A351/A351M-08 stainless steel and hydraulically balanced. The impeller shall be dynamically balanced to ANSI Grade G6.3 and shall be fitted to the shaft with a key. The impeller shall be cast by the hydraulically efficient lost foam technique to ensure repeatability of high quality.
6. The pump shall be manufactured with ASTM A582 Type 416T or ASTM A582 Type 410T stainless steel shaft.
7. The pump shall be fitted with a single mechanical seal, with EPT elastomers and Carbon/Ceramic faces, rated up to 250°F. This seal must be capable of being flushed externally via a tapping in the pump cover adjacent to the seal cavity. The entire pump line shall use no more than three different sizes of seals.
8. The pump shall be coupled via a high tensile aluminum split style coupling. The design must permit easy replacement of the mechanical shaft seal without removal of the motor. The motor mount must be designed to accept several different motor frame standards; CZ and HP.
9. To both simplify and reduce the total cost of ownership; the manufacturer shall standardize on no more than three sizes of mechanical seals throughout the entire range of the family of pumps. The manufacturer shall not use multiple part numbers for the same part.

C. VERTICAL CLOSED COUPLED PUMPS

1. Pumps shall be Taco Model KV or approved equal. The pumps shall be vertical inline design. The capacities and characteristics shall be as called for in the plans/schedules.
2. Pump casing shall be constructed of ASTM A48 class 30 cast iron. The pump casing/volute shall be rated for 250 psi working pressure for all jobs. The pump flanges shall be matched to suit the working pressure of the piping components on the job, with ANSI Class 125 flanges. The pump casing shall be drilled and tapped for gauge ports on both the suction and discharge connections and for a drain port at the bottom of the casing. The casing shall have an additional tapping on the discharge connection to allow for the installation of a seal flush line. The pump cover shall be drilled and tapped to accommodate a seal flush line which can be connected to the corresponding tapping on the discharge connection, or to an external source to facilitate cooling and flushing of the seal faces.
3. All casings shall be flanged. Threaded casings not allowed unless extra unions and fittings are provided with that pump to allow servicing.
4. The pump shall have a factory installed vent/flush line to insure removal of trapped air from the casing and mechanical seal cooling. The vent/flush line shall run from the seal chamber to the pump discharge.



5. The impeller shall be ASTM B584-836/875 bronze and hydraulically balanced. The impeller shall be dynamically balanced to ANSI Grade G6.3 and shall be fitted to the shaft with a key. The impeller shall be cast by the hydraulically efficient lost foam technique to ensure repeatability of high quality.
6. The pump shall incorporate a dry shaft design to prevent the circulating fluid from contacting the shaft. The pump shaft shall be AISI 1045 carbon steel with field replaceable bronze SAE 660 shaft sleeve. To improve serviceability and reduce the cost of ownership the shaft sleeve must be slip on (press on not allowable) and must be easily replaced in the field.
7. The pump shall be fitted with a single mechanical seal, with EPT elastomers and Carbon/Ceramic faces, rated up to 250°F. This seal must be capable of being flushed externally via a tapping in the pump cover adjacent to the seal cavity. The entire pump line shall use no more than three different sizes of seals.
8. The pump shall be close coupled to a NEMA standard JM frame motor.
9. To both simplify and reduce the total cost of ownership; the manufacturer shall standardize on no more than three sizes of mechanical seals throughout the entire range of the family of pumps. The manufacturer shall not use multiple part numbers for the same part

3.2 SUCTION DIFFUSERS

- A. Suction diffuser shall have integral cast straightening vanes to ensure uniform flow to the suction inlet of the pump.
- B. Suction diffuser shall have oversized body cylinder to ensure minimal pressure drop.
- C. Suction diffuser shall have a disposable fine mesh start-up strainer to promote a cleaner, more trouble-free system.
- D. Suction diffuser shall have a blow down port to allow for routine maintenance and removal of sediment and debris.
- E. Suction diffuser shall have Class 125 ANSI flanges.
- F. Suction diffuser body and cover shall be of Ductile Iron.
- G. Suction diffuser shall have integral ductile iron straightening vanes with a stainless-steel permanent strainer and bronze (16 Mesh) disposable start up strainer.

3.3 MOTORS

- A. Motors shall comply with NEMA MG 1 and shall be inverter rated.



B. Duty: Motors shall be continuous duty at ambient temperature of 40 deg C.

C. Capacity and Torque Characteristics: Motors shall be sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

D. Service Factor: 1.15

E. All motors operated on variable frequency drives shall be equipped with a shaft grounding ring. Grounding ring shall be provided and installed by the motor manufacturer or contractor in accordance with the manufacturer's recommendations. Shaft grounding ring shall be manufactured by AEGIS.

F. Enclosure:

1. Provide total-enclosed, fan-cooled (TEFC) enclosures for motors installed outside, in roof mounted equipment or exposed to environments with relative humidity exceeding 60% for more than 5 hours per year.
2. Open, drip proof (ODP) motors can be provided for all other applications.

G. Insulation:

1. Motors 7.5 HP and larger: Class F
2. Motors less than 7.5 HP: Class H

H. Frame Material:

1. Motors 15 HP and larger: Iron
2. Motors less than 15 HP: Steel

I. Acceptable Manufacturers: Baldor Reliance, Marathon, or approved equal.

3.4 VARIABLE FREQUENCY DRIVES

A. ABB ACS series variable frequency drives or approved equal or ABB ACH Series variable frequency drives or approved equal shall be provided as standard on the pump skids.

B. If ACS series drive or approved equal is provided;

1. The drive manufacturer shall supply the drive and all necessary options as specified. All drives installed on this project shall be from the same manufacturer and have a common user interface (control panel). The manufacturer shall have been engaged in the production of this type of equipment for a minimum of 30 years. Drives that are manufactured by a third party and "brand labeled" shall not be acceptable. Drive manufacturers who do not build their own power boards and assemblies, or do not have full control of the power board manufacturing and quality control, shall be considered as a "brand labeled" drive.



2. Drives shall be UL labeled as a complete assembly. The base VFD shall be UL listed for 65 kA SCCR when installed in accordance with the manufacturer's guidelines.

3. Drives shall be capable of continuous full load operation under the following environmental operating conditions:

Ambient temperature -10 to 50° C (14 to 122° F).

Altitude 0 to 1000 m (0 to 3,300 ft) above sea level.

Humidity 5 to 95%, non-condensing.

4. I/O Summary display with a single screen shall indicate and provide the status/values of inputs and outputs.

5. The control panel shall include assistants specifically designed to facilitate start-up.

6. Primary settings for HVAC shall provide quick set-up of all parameters and customer interfaces to reduce programming time.

7. All drives shall have the following hardware features/characteristics as standard:

- Two (2) programmable analog inputs shall accept current or voltage signals. Current or Voltage selection configured via control panel. Drives that require access to internal components to perform these functions, are not acceptable.
- One (1) programmable analog output. Analog output shall be adjustable for current signal, configured via control panel. Drives that require access to internal components to perform these functions, are not acceptable.
- Five (5) programmable digital inputs. The digital input shall be capable of accepting 24 VDC.
- One (1) programmable relay output. The relay shall be rated for a continuous current rating of 2 Amps. Maximum switching voltage of 250 VAC / 30 VDC.
- One (1) programmable digital output. The digital output shall be of transistor output type with maximum switching voltage of 30 V DC.

8. The drive shall have cooling fans that are designed for field replacement. The primary cooling fan shall operate only when required.

9. All drives shall have the following software features as standard:

- A Fault Logger that stores the last 10 faults.
- Programmable start method. Start method shall be selectable based on the application: Flying-start, Normal-start.
- Motor heating function to prevent condensation build up in the motor.



- The ability to automatically reset after an over-current, over-voltage, under-voltage, external and “analog input below a minimum” faults.

10. Network Communications

- The drive shall have an EIA-485 port with removable terminal blocks. The onboard protocols shall be BACnet MS/TP, Modbus, Johnson Controls N2, Siemens Building Technology FLN (P1).

C. If ACH580 series drive or approved equal is provided;

1. The drive manufacturer shall supply the drive and all necessary options as specified. All drives installed on this project shall be from the same manufacturer and have a common user interface (control panel). The manufacturer shall have been engaged in the production of this type of equipment for a minimum of 30 years. Drives that are manufactured by a third party and “brand labeled” shall not be acceptable. Drive manufacturers who do not build their own power boards and assemblies, or do not have full control of the power board manufacturing and quality control, shall be considered as a “brand labeled” drive.

2. Drives shall be UL labeled as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR when installed in accordance with the manufacturer’s guidelines.

3. Drives shall be capable of continuous full load operation under the following environmental operating conditions:

Ambient temperature -15 to 40° C (5 to 104° F).

Altitude 0 to 1000 m (0 to 3,300 ft) above sea level.

Humidity 5 to 95%, non-condensing.

4. I/O Summary display with a single screen shall indicate and provide:

- The status/values of all analog inputs, analog outputs, digital inputs, and relay outputs. Drives that require access to internal or live components to measure these values, are not acceptable.
- The programmed function of all analog inputs, analog outputs, digital inputs, and relay outputs.
- The ability to force individual digital I/O high or low and individual analog I/O to desired value, for increased personal protection during drive commissioning and troubleshooting. Drives that require access to internal or live components to perform these functions, are not acceptable.

5. The control panel shall include assistants specifically designed to facilitate start-up. Assistants shall include: First Start Assistant, Basic Operation, Basic Control, and PID Assistant.

6. Primary settings for HVAC shall provide quick set-up of all parameters and customer interfaces to reduce programming time.



7. All drives shall have the following hardware features/characteristics as standard:

- Two (2) programmable analog inputs shall accept current or voltage signals. Current or Voltage selection configured via control panel. Drives that require access to internal components to perform these functions, are not acceptable.
- Two (2) programmable analog outputs. At least one of the analog outputs shall be adjustable for current or voltage signal, configured via control panel. Drives that require access to internal components to perform these functions, are not acceptable.
- Six (6) programmable digital inputs. All digital inputs shall be programmable to support both active high and active low logic and shall include adjustable on/off time delays. The digital input shall be capable of accepting both 24 VDC and 24 VAC.
- Three (3) programmable Form-C relay outputs. The relay outputs shall include programmable on/off time delays. The relays shall be rated for a continuous current rating of 2 Amps. Maximum switching voltage of 250 VAC / 30 VDC. Open collector and Form-A relays are not acceptable. Drives that have less than (3) Form-C relay outputs shall provide an option card to provide additional relay outputs.

8. The drive shall have cooling fans that are designed for field replacement. The primary cooling fan shall operate only when required and be variable speed for increased longevity and lower noise levels. Drives whose primary cooling fans are not variable speed, shall include a spare cooling fan.

9. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds every minute. The minimum current rating shall meet or exceed the values in the NEC/UL table 430.250 for 4-pole motors.

10. All drives shall have the following software features as standard:

- A Fault Logger that stores the last 16 faults in non-volatile memory.
- An Event Logger that stores the last 16 warnings or events that occurred, in non-volatile memory. Events shall include, but not limited to: Warning messages, checksum mismatch, run permissive open, start interlock open, and automatic reset of a fault. The date and time of each event's start and completion points shall be stored in the Event Logger.
- Programmable start method. Start method shall be selectable based on the application: Flying-start, Normal-start, and Brake-on-start.
- Programmable loss-of-load (broken belt / coupling) indication. Indication shall be selectable as a control panel warning, relay output, or over network communications. This function to include a programmable time delay to eliminate false loss-of-load indications.



- Motor heating function to prevent condensation build up in the motor. Motor heating adjustment, via parameter, shall be in “Watts.” Heating functions based only on “percent current” are not acceptable.
- The ability to automatically restart after an over-current, over-voltage, under-voltage, external fault, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable. Each of these faults may have automatic restart individually disabled via a parameter selection.

11. Network Communications

- The drive shall have an EIA-485 port with removable terminal blocks. The onboard protocols shall be BACnet MS/TP, Modbus, and Johnson Controls N2. Optional communication cards for BACnet/IP, LonWorks, Profibus, Profinet, EtherNet/IP, Modbus TCP, and DeviceNet shall be available.
- The drive shall have the ability to communicate via two protocols at the same time, one onboard protocol and one option card-based protocol. Once installed, the drive shall automatically recognize any optional communication cards without the need for additional programming.

12. Optional Disconnect – A circuit breaker or disconnect switch shall be provided when requested by the customer. The disconnect shall be door interlocked and padlockable.

3.5 VIBRATION ISOLATION

A. Vibration isolation sufficient for each application (type, quantity, deflection) shall be selected. Options include: i) ASHRAE Type 1 (rubber mounts) isolators for smaller skid applications or for isolating mounted pumps from the skid base; ii) ASHRAE Type 3 (spring) isolators for indoor non-seismic larger skid applications; iii) ASHRAE Type 4 (restrained spring) isolators for outdoor or seismic applications.

B. ASHRAE Type 1 (rubber mounts) isolators: - Type 1 isolators shall be of natural rubber for superior resistance to tears and abrasion as well as good flexibility in cold temperatures. Isolators to be installed between surfaces inside pump skid such as between the pumps and skid base to minimize vibration. Isolators shall be for use in compression and shear load applications.

C. ASHRAE Type 3 (Spring) Isolators: - Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4” (6mm) neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Installed and operating heights shall be equal. The ratio of the spring diameter divided by the compressed spring height shall be no less than 0.8. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Mountings shall be type SLF as manufactured by Mason Industries, Inc.



D. ASHRAE Type 4 (Restrained Spring) Isolators: - When the equipment is at full operating weight, the springs shall be adjusted to assume the weight and the spacers removed, without changing the installed and operating heights. All restraining bolts shall have large rubber grommets to provide cushioning in the vertical as well as horizontal modes. The hole through the bushing shall be a minimum of 0.75" (19mm) larger in diameter than the restraining bolt. Horizontal clearance on the sides between the spring assembly and the housing shall be a minimum of 0.5" (13mm) to avoid bumping and interfering with the spring action. Vertical limit stops shall be out of contact during normal operation. Housings and springs shall be powder coated and hardware electro-galvanized. Mountings shall be SLRSO as manufactured by Mason Industries, Inc.

E. For all vibration isolator types, single-sphere molded rubber expansion joints shall be provided on either side of each pump.

F. Vibration isolators, if selected, shall be provided by run-around glycol system manufacturer. However, installation of spring or restrained spring vibration isolators shall be done at the job site by others.

3.6 AIR AND DIRT SEPARATOR

A. Separator shall be designed and constructed per ASME Code Section VIII Div. 1 and registered with the National Board of Pressure Vessel Manufacturers.

B. Separator shall have a standard design pressure and temperature of 125 psi at 240°F

C. Separator shall have particle removal down to 5 microns

D. Separator shall have factory installed air vent suitable for water and up to 50% glycol

E. Separator shall have factory installed blowdown and flush valves

F. Separator shall be of carbon steel construction with stainless steel pall rings.

G. Separator shall have Class 125 ANSI flanges.

F. Acceptable manufacturers: - TACO 4900 Series or approved equal.

3.7 EXPANSION TANK

A. Expansion tank shall be designed and constructed per ASME Code Section VIII Div. 1 and registered with the National Board of Pressure Vessel Manufacturers.

B. Expansion tank shall have a standard design pressure and temperature of 125 psi at 240°F

C. Expansion tank shall be bladder type for permanent separation of air and water.



- D. Elastomeric bladder, removable for inspection shall be provided.
- E. Water shall expand into bladder, air pre-charge on shell side.
- F. Acceptable manufacturers: - TACO CBX or CA Expansion Tanks or approved equal.

3.8 GLYCOL FEED EQUIPMENT

- A. When present, glycol feed equipment shall have minimum 50-gallon tank mounted in a steel frame.
- B. A bronze rotary gear pump (minimum 1.5 gpm at 100 psi) shall be provided.
- C. A float switch for low level pump alarm shall be provided.
- D. Control panel shall be NEMA 4x rated.
- E. Factory on/off range shall be 40-60 PSI with an adjustable differential of 15 to 30 PSI.
- F. Acceptable manufacturers: Eddington Industries or approved equal.

3.9 LIQUID-TO-LIQUID HEAT EXCHANGERS (OPTIONAL)

- A. Brazed plate heat exchangers constructed of 316 stainless steel shall be provided.
- B. The heat exchanger shall be constructed as a plate package of corrugated channel plates with a filler material between each plate.
- C. Heat exchangers shall be installed such that they can be cleaned in place.
- D. Heat exchangers shall be installed such that they can be removed and replaced, if necessary.
- E. Heat exchangers shall be manufactured by a company that maintains both AHRI Standard 400 Certification for Liquid-to-Liquid Brazed & Fusion Bonded Plate Heat Exchangers and UL/ETL certification.
- F. Acceptable Manufacturers: SWEP, Alfa Laval

3.10 VALVES AND SPECIALTIES

A. Butterfly Valves

1. Valves shall be for use with ANSI Class 125/150 flanges
2. Valve body shall be ductile iron ASTM A536
3. Valve disc shall be of aluminum bronze or 304 stainless steel
4. Valve shall be lug style with lever style handles for valve sizes 6 inches and smaller and gear style handles for valve sizes above 6 inches.



5. Valve shall have minimum 200 psi body pressure rating and 200 psi close-off pressure rating.

6. Acceptable Manufacturers: Milwaukee Valve, Belimo Valve, Siemens or Approved Equal.

B. Check Valves

1. Check valves shall be horizontal swing style with flanged ends.

2. Valves shall be for use with ANSI Class 125/150 flanges

3. Valves shall conform to MSS SP-71

4. Valve body shall be cast iron ASTM A126, Class B

5. Valves shall be installed as far as possible from the pump and elbows with a minimum distance of 5 times the pipe diameter

6. Acceptable Manufacturers: Milwaukee Valve or Approved Equal.

C. Pressure Independent Control (PIC) Valves

1. PIC Valve shall integrate three functions into a single device: control valve, adjustable flow limiter and automatic differential pressure regulator.

2. Valves shall have ANSI Class IV leakage ($\leq 0.01\%$)

3. Valves shall be provided with ANSI Class 125 flanges

4. Valves shall have a minimum close off pressure of 100 psi with hot water, chilled water, and water/glycol solution as permissible media.

5. Valve shall allow for a medium temperature up to 240°F

6. Valve body shall be cast iron with stainless steel stem, spring, and seat.

7. Acceptable Manufacturers: Siemens or Approved Equal.

D. Multi-Purpose Valves

1. Multi-purpose valves shall integrate 5 valves in a single device: shut off valve, flow control valve (globe style), non-slam check valve, flow metering valve, straight pattern valve convertible to a right-angle pattern valve.

2. Valves shall be provided with Class 125 flanges.



3. Valves shall be for horizontal or vertical installation
3. Valve shall allow for a medium temperature up to 240°F
4. Valve body shall be of ductile iron with stainless steel or bronze spring, stem and seat disc.
5. Acceptable manufacturers; TACO or Approved Equal.

E. Pressure Relief Valves

1. All pressure relieving devices shall be approved and certified by ASME Boiler Section VIII
2. Relief valve body shall be of brass/bronze material.
3. Relief valve ring, disc and springs shall be of stainless-steel material.
4. Pressure relief valve shall be suitable for maximum system operating pressure and temperature.
5. Acceptable manufacturers: Aquatrol, Kunkle, Watts, Consolidated, Apollo

3.11 SKID PIPING

- A. Skid piping shall be located such that access to equipment is maintained.
- B. Accessible flanges and/or union connections shall be provided on the supply and return connections of equipment which must be disconnected for servicing.
- C. Adequate piping support for the skid piping shall be provided by skid manufacturer.
- D. Piping support shall allow space for pipe insulation to be installed at the job site by others.
- E. Piping support shall be of materials compatible with the materials of the piping or equipment.
- F. All flanges except for those on components already detailed shall be ANSI Class 150 flanges.
- G. Gaskets to ASTM D2000, for ANSI Class 150 flanges and compatible with pipe flanges shall be used.



PART 4 – EXECUTION

4.1 SYSTEM STARTUP

- A. Pump skid shall be tested in manufacturer's facility. This includes programming VFDs and the controller configured for this project.
- B. System Start-up shall be provided by others and shall include the following:
- C. On-site start-up:
- D. Review/inspection of heat exchanger installation and piping
- E. Review/inspection of sensors and valves installations
- F. Inspection/programming of pump variable frequency controllers.
- G. Functional testing of valves and variable frequency controllers.
- H. Testing of interface with Building Management System
- I. Instruction of operating/maintenance staff for a period of 8 working hours at project work site.
- J. Start-up takes place in cooperation with HVAC and BMS suppliers

4.2 INSTALLATION (PROVIDED BY OTHERS)

- A. Install heat exchangers (coils) and hydronic module in compliance with system manufacturer's installation guidelines.
- B. Install piping, valves, and other interconnecting systems. Control valves located remotely at each supply and exhaust coil bank are provided by system manufacturer but field mounted and wired back to the hydronic module by the contractor.
- C. Insulate piping including piping on hydronic module.
- D. Flush piping and fill system with Glycol / Water mixture as defined in the coil data sheet.
- E. Install sensors in AHUs/MAUs and connect to the energy recovery system's electrical/control cabinet

4.3 PERFORMANCE MONITORING AND GUARANTEE

- A. HPT shall provide this pumped system performance guarantee on the condition that all the necessary and required data is timely provided by the customer to HPT. System performance shall be monitored jointly by HPT and the customer in the first year of



operation. The customer shall provide the required system data values for those variables requested by HPT at the requested intervals throughout the year.

- B. If the HPT system does not perform in accordance with the specifications provided by HPT after successful startup, and such failure is not due to any act, omission, negligence or misconduct of the customer, HPT shall reimburse the customer for its excess energy cost accrued during the first year of operation up to a maximum of 15% of HPT's quoted equipment cost. Excess energy cost is defined as the difference between the quoted energy savings per year and the actual energy savings under the identical conditions during the prior year based on the documentation provided by the customer.
- C. The customer shall have the option to purchase an extended Performance Guarantee from year two to year five (i) in accordance with the HPT-provided performance specifications, and (ii) under the same terms and conditions stated in Section 4.3(B). If the HPT system does not perform in accordance with the specifications provided by HPT, and such failure is not due to any act, omission, negligence or misconduct of the customer, HPT shall reimburse the customer's excess energy cost during year 2 to year 5 of operation up to a maximum of 15% of HPT's quoted equipment cost but not to exceed a cumulative maximum of 25% of HPT's quoted equipment cost when accounting for year 1 (4.3B) as well as year 2 through year 5.
- D. In no event will HPT be liable to the customer or any third party for any direct, incidental, special, indirect, exemplary, consequential or punitive damages of any kind arising out of or relating to this agreement. HPT's liability is limited to the maximum amount stated in Section 4.3(B) and (C) above, as applicable. HPT does not warrant that this guarantee will apply to future systems, or any other future work performed.

END OF SECTION