PART 1 - INTRODUCTION

1.1 PURPOSE

A. This section refers to the requirements for Building Heat Exchanger Systems.

PART 2 - GENERAL DESIGN REQUIREMENTS

2.1 DESIGN and ENGINEERING

A. Heat Exchanger Applications
   1. Heating, steam as source side:
      a. Shell and Tube Type, shell side shall be steam.
   2. Process Chilled Water, Plant Chilled Water as source side:
      a. Plate and Frame type.

B. Heat Exchanger Design Parameters:
   1. Shell and Tube
      a. Shell, Source Side:
         1) Steam Pressure: 5 psig
      b. Tube, Load Side:
         1) Hot Water: LWT, and EWT to be project specific.
         2) Fouling factor 0.001
         3) Select HX on recommended manufacturer fluid velocity minimum, and maximum values. Do not exceed 6 FPS for tube side of HX.
         4) Pressure drop at design flow shall not exceed 3.5 psi.
   2. Plate and Frame
      a. Margin: 5%, Select HX with additional surface area to account for fouling. Margin is defined as M = (kc-k) / k; where k = heat transfer coefficient.
      b. Pressure drop at design flow shall not exceed 3.5 psi. Delta P shall not fall below manufacturer minimum velocity recommendations.
      c. Frame size shall allow for increased capacity, 25%.

C. Install fully redundant (N+1) system. Redundancy shall include pumping systems, and allow for the complete service, repair, and replacement of any one component without requiring the interruption of service.

D. Provide appropriate ASME rated pressure relief valve on shell side of heat exchanger, and vent pipe to exterior atmosphere, and or code approved location.

E. Provide appropriate ASME rated water pressure and temperature relief valve, for tube side of HX.

F. Load and source side connections shall include appropriate T & P gauges, gauges shall have ball type isolation valves.

G. Pumping system shall conform to HVAC Pump standard requirements.

H. Consultant shall verify building steam source profile for seasonal variations.
I. Shell side of HX shall have lockable bypass valve at control valve for warm up cycling.
J. There shall be separate heating systems for perimeter and reheat systems.
K. The condensate trap shall be sized for 150% of design load at no greater than 0.5 psig, and in no case shall the condensate trap be sized less the warm up load.
L. Stationary equipment shall be placed on a minimum four inch high concrete housekeeping pad, and secured with heavy duty anchors.

2.2 Install shell-and-tube heat exchangers on cast steel saddle supports, and on a painted rust resistant frame. Frame shall be fabricated of welded angle iron, members shall be a minimum of 2x2x1/4. Legs shall have 6x6x1/2 plates. The top of frame shall be a minimum of four feet AFF.

2.3 The discharge height of the HX condensate shall be of sufficient height for proper operation of condensate trap, and for condensate trap to discharge via gravity to point of collection. The use of electric condensate pumps is prohibited.

2.4 Heat exchangers for DHW systems shall comply with the requirements of NSF 61 (no-lead), IPC, and the Connecticut Cross Connection Code.

2.5 CONTROLS

A. In most cases design steam to water heat exchanges to have multiple operating valves, with a 1/3, 1/3, 1/3 modulating steam control valve configuration. Where the load is not of sufficient capacity a two or less operating valve approach may be pursued, but requires review and approval by Yale Facility Engineering.
B. Control strategies shall implement resetting source and load parameters (Volume and Temperature) based on load, and environmental factors.

2.6 OPERATION AND MAINTENANCE REQUIREMENTS

A. Provide a minimum of 36 inch working clearance around the perimeter of the system, and conform to manufactures minimum clearance requirements. The greater of the two clearance requirements shall apply.
B. Provide sufficient clearance to remove the HX bundle and or plates.
C. Heat exchanger will be provided with Hydronic Makeup Flow Protection on the cold-water fill line for the Steam Heat exchanger hot water heating system and the cold-water fill line for the flat plate heat exchanger secondary cooling system to isolate the fill line and shut down the associated Heat exchanger in the event of a leak.
D. Water make-up flow sensors shall be provided and integrated into the BMS/BAS software. Sequence of operations is as follows:
    1. Normal Conditions: A 24v Electronic control isolation ball valve is de-energized and open. Feedback on the valve also reads open. Water make-up flow sensor reads "normal" (closed contact state) with no make-up water flow.

2. Leak Conditions: Flow sensor will detect flow (open contact state) after its set point of 2 GPM is exceeded and the Building Automation System (BAS) will show the water makeup Flow sensor reading "Flow". If the flow sensor remains in 'Flow" for more than 5 minutes a software "Make-up" alarm will be generated.
3. The Water System Leak Alarm will:
4. Close the make-up isolation valve, valve feedback will the then show "closed" in Alarm. Shut off associated pumps and heat exchanger steam control valves.
5. The Water System leak alarm will remain in Alarm until it is manually reset in software. The reset will clear the alarm and open the isolation valve.
6. A software "makeup alarm override" will also be provided which will bypass the logic of the "Make-up" Alarm to keep the makeup isolation open, the pumps running normally and the Heat exchanger steam valve enabled.

E. Isolation valves shall be provided for both the load and source side of the equipment. Additionally, a lockable bypass valve, and a test (calibration) drain valve will be provided. The valves shall be labeled, located in the same MER, accessible without the use of a ladder, and allow for the removal of equipment without having to remove pipe.
F. Each control valve shall be serviceable and removable without interruption of service.
G. Each heat exchanger shall be provided with isolation valves, including duplex package units.
H. Steam heat exchangers shall be provided with a bypass pipe and throttling valve at the inlet side of the HX to provide manual warm-up.
I. Design heat exchanger piping so that the heat exchanger can be backwashed. Include a floor drain of sufficient size to accommodate the backwash.
J. Provide a hose-end valve to drain the shell.

PART 3 - MINIMUM PRODUCT CRITERIA

3.1 ACCEPTABLE MANUFACTURERS

A. Shell and Tube
   1. Armstrong
   2. Bell and Gossett
B. Plate and Frame
   1. Tranter
   2. Alfa-Laval

3.2 SHELL AND TUBE TYPE HEAT EXCHANGER

A. The heat exchangers shall be of the shell and tube type design, with fabricated channel type head. The tube bundle shall be removable "U-tube" construction with tube ends expanded

into a stationary tube sheet. The construction shall permit expansion and contraction of the tube bundle from room temperature of 70ºF to operating temperature of 450ºF or vice versa. The hot water (hot fluid) shall be circulated through the tubes.

B. All connections shall be flanged. Tube side flanges shall be ANSI Class 300 lb. Shell side flanges shall be ANSI Class 300 lb.

C. The heat exchangers shall be provided with adjustable steel or cast iron saddle type supports with a threaded steel U-bolt or steel strap. The support legs shall be drilled to accommodate mounting bolts.

D. Heat exchangers utilizing an essentially toxic transfer fluid shall be separated from the by double-wall construction. An air gap open to the atmosphere shall be provided between the two walls. Heat exchangers utilizing an essentially nontoxic transfer fluid shall be permitted to be of single-wall construction, if acceptable by governing codes. See plumbing standards for potable water HX requirements.

E. The heat exchangers shall be provided with sufficient number of drain connections to completely drain the unit. Necessary drain locations shall be determined by the heat exchanger manufacturer.

F. The heat exchangers shall be provided with a flanged connection on the shell-side for a safety relief valve (SRV). Location and size of the connections shall be as shown on the Drawings. The flanges shall be ANSI Class 300 lb.

G. The heat exchanger materials of construction shall be as follows:

1.	Shell	Carbon Steel
2.	Head, Bonnet	Carbon Steel
3.	Tie Rods/Spacers	Carbon Steel
4.	Tube Sheet	90/10 Cupro-Nickel
5.	Baffles	Carbon Steel
6.	Gaskets	Spiral Wound (304 Stainless Steel with Graphite Filler)
7.	Nuts and Bolts	Carbon Steel (B7 bolts, 2H nuts)
8.	Tubes	90/10 Cupro-Nickel
9.	Tube O.D.	0.75"
10.	Tube thickness minimum:	18 BWG
11.	Fouling factor:	0.001

H. The heat exchangers shall be constructed and tested in accordance with the latest ASME Code for Unfired Pressure Vessels. Form No. U-1, as required by the provisions of the ASME Code Rules, shall be furnished to the Owner. The form must be signed by an authorized inspector, holding a National Board commission, certifying that the construction meets the code requirements for the design pressure and temperature shown on the project documents and as detailed in Form No. U-1. Each heat exchanger shall be registered with

the National Board of Boiler and Pressure Vessel Inspectors and shall have the ASME "U" symbol stamped on the heat exchanger.

3.3 PLATE AND FRAME HEAT EXCHANGER

A. HX shall be certified to AHRI 400 specifications and standards.

B. HX submittal shall state HX selection complies with AHRI 400 requirements and is certified per AHRI 400.

C. The Plate and Frame HX shall have the following features.
   1. Movable rear cover
   2. Fixed Cover
   3. Frame feet
   4. Carrying bar
   5. Inspection cover/port
   6. Guide Bar
   7. Support column.
   8. Roller assembly
   9. Stainless Steel shroud, with rigid insulation.
   10. Stud type bolt flange connections.
   11. All non-stainless parts shall be painted, excluding threaded rod and bolts.

D. Plate and Frame Heat Exchanger: Preassembled freestanding unit consisting of a unitized frame, embossed plates, smooth finished stainless-steel clad top and bottom guide bars and related accessories, pressure tested in accordance with ASME Code. The HX shall be rated for 150 psig, and no less than 1.3 times the working pressure. The larger of the two values shall apply.

E. Plates: Type 304 or 316 stainless steel as scheduled, herringbone or washboard design with alternate plates rotated at 180º. Plates shall be no less than 0.024" thick and shall be provided with tapered side grooves for the entire gasket. Gasket shall be EPDM rubber secured into the gasket groove. Gaskets shall not be glued.

F. Nozzles: 316L stainless steel, 150 psi, ASA rated.

G. Nuts and Bolts: Zinc plated.

H. Frame: Capacity to accommodate 25 percent additional plates.

I. Margin: 5%, Select HX with additional surface area to account for fouling. Margin is defined as M = (kc-k) / k; where k = heat transfer coefficient.

3.4 Quality Assurance:

1. Product Options: Drawings indicate size, profiles, performance, and dimensional requirements of heat exchangers and are based on the specific equipment indicated.
2. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

3. Registration: Fabricate and label shell-and-tube heat exchangers to comply with the Tubular Exchanger Manufacturers Association's standards.
4. Plate and Frame heat exchangers shall be AHRI 400 performance certified.

Date	Description of Change	Pages / Sections Modified	ID
6/15/16	Entire document	-	mlamore
08/01/21	Added acceptable mfg, and updated selection criteria for P&F HX.	-	mlamore