Delete the following current subsection .01 from Section 23 70 00 in its entirety (deletions are shown struck through).

23 57 00 HEAT EXCHANGERS FOR HVAC

~~**.01 Heat Exchangers**~~

~~A. Plate and frame heat exchangers shall typically be specified in water to water and steam to water applications.~~
~~1. Heat exchangers shall be of bolted construction with heavy duty frame heads.~~
~~2. Plates shall be of 316 stainless steel construction and shall be gasketed to prevent cross contamination.~~
~~B. Shell and tube heat exchangers may be used if plate and frame units are inappropriate for the application.~~
~~1. Converters shall have steam in the shell and water in the tubes. Tubes shall be 90-10 cupro nickel, ASTM B-111, and velocity shall be less than five (5) feet per second.~~
~~2. Provide sufficient clear space to allow for tube bundle removal. (No less than the entire length of the converter.)~~
~~3. Tube bundles shall be straight tube design. A spare tube bundle shall be provided as part of the contract.~~
~~C. ASME rating is required.~~
~~D. A relief valve sized at not greater than the heat exchanger's maximum working pressure shall be installed on the water side of each steam/hot water heat exchanger. Since PA L&I currently considers chilled water heat exchangers to be unfired pressure vessels, provide relief valves on both the building chilled water side and campus chilled water side. The relief valves must be installed at the heat exchanger and prior to the isolation valves. The relief valve should be sized by the design professional.~~
~~E. Install vacuum breakers in piping for modulating steam supply and minimum 18" drip leg to trap inlet.~~
~~F. Converters shall be selected at 2 psig steam supply and .0005 fouling factor. Control valves shall be sized for a steam entering pressure of 8 psig with a 6 psi maximum drop through the valve.~~

Replace with the following subsections .01, .02 and .03 and associated text.

23 57 00 HEAT EXCHANGERS FOR HVAC

.01 Owner General Requirements

A. Summary: Section includes requirements for shell-and-tube and plate type heat exchangers in HVAC applications.

B. General Requirements:

1. Professional shall design each heat exchanger application for optimal operating efficiency, reliability, flexibility, and ease of maintenance with the lowest life cycle cost.
    a. Design for efficient and stable system operation: Professional shall determine the anticipated minimum and maximum loads for each system and evaluate most appropriate number, combination and arrangement of exchangers for optimal system efficiency and stable operation over entire operating range.
        i. In variable flow pumping systems, minimum velocities to avoid laminar conditions to maintain adequate heat exchange capacity shall be maintained with minimum anticipated hydronic system flows.
        ii. Maximum velocities shall not be exceeded to avoid erosion of tube surfaces.
        iii. Ensure only dry steam enters the control valve and heat exchanger inlet to avoid water hammer or damaging tubes due to wet steam impingement.
    b. Reliability/Redundancy: Professional shall determine the consequences of system failure and provide for adequate system redundancy for each application.
        i. Install fully redundant (N+1) stand-by units for extremely critical applications (such as critical research laboratories and computer centers) and/or as otherwise defined specifically in the Owner's Project Requirements.
        ii. For non-critical applications (such as general office spaces, general purpose classrooms, general commercial type spaces) full redundancy/complete standby is typically not required. In such cases two (2) units in parallel, each sized for a minimum of approximately 75% of maximum load may be considered. This arrangement offers greater flexibility and turndown and still provides majority of capacity when one of the units is out of operation for any reason.
        iii. On applications with a single heat exchanger assembly, install a manual bypass assembly with globe valve around the temperature control valve(s) and strainer to allow emergency servicing of control valve(s) or strainer without complete shutdown.
    c. Flexibility: Consider potential future expansion. Extent of expansion will be determined on a case-by-case basis. Consult with the University Project Leader and Engineering Services.
    d. Controls:

i. Select arrangement of control valve(s) for each heat exchanger for most appropriate turndown for anticipated operating range.
ii. Coordinate control devices and operational sequences with Section 25 00 00 INTEGRATED AUTOMATION and 25 90 00 GUIDE SEQUENCES OF OPERATION

e. Maintenance:
i. Locate in safe and convenient area and provide convenient means for frequently inspecting and cleaning.
ii. Provide valves and bypasses in the piping so unit may be bypassed when required to permit isolation for inspection and repairs with interrupting main systems.

2. Equipment Layout:
a. Comply with all Space Planning Requirements indicated in 01 05 05.02 Planning for Engineered Building Systems.
b. Maintain minimum recommended service clearances of 36" around service ends of heat exchangers and 24" in general.
c. Maintain minimum clearances for tube pull and/or cleaning of tubes as recommended by the equipment manufacturer, typically no less than the length of the heat exchanger.
d. Coordinate structural reinforcements and other provisions for rigging of tube bundles for future removal and replacement.
e. Dimensions, sizes, weights and locations of heat exchangers must take into account how they can be easily moved in and out of building both during and after initial construction for installation and/or replacement.
f. For hot water applications, install pumps on the cooler return water side of the heat exchanger. The lower operating temperature helps to extend mechanical seal life.

3. Seismic Performance: Coordinate project specific seismic restraint requirements with structural engineer.

C. Types, Applications and Selection Criteria:
1. General: Heat exchangers for HVAC applications shall be rated for minimum of **150 psig** working pressure at 375ºF, or higher if otherwise required to provide rated working pressure of at least 1.5 times maximum operating pressure.
a. A relief valve sized at not greater than 90% of the heat exchanger's maximum working pressure shall be installed on the water side of each steam/hot water heat exchanger and on both sides of water to water units. The relief valves must be installed at the heat exchanger and prior to the isolation valves.

b. Since PA L&I currently considers chilled water heat exchangers to be unfired pressure vessels, provide relief valves on both the building chilled water side and campus chilled water side.
c. The relief valves selection parameters shall be determined and scheduled by the design professional.

2. Shell and Tube "Converter" type:
   a. Applications include:
      i. Steam to hot water HVAC systems.
      ii. Water to water with design approaches typically greater than 15ºF.
      iii. Special high temperature and/or pressure separation requirements of parts of a system or systems with large differences or fluctuations in temperature or pressures between fluid sides.
   b. Selection Criteria
      i. Converters shall have steam in the shell and water in the tubes. For high temperature difference water to water systems, lower temperature water to heated shall be in the tubes.
      ii. Converters shall typically be selected at **2** psig steam pressure operating in the shell for most efficient operation heating fluids up to 200 ºF. Otherwise select a steam pressure that has a saturation temperature approximately 30 ºF higher than the required outlet temperature of the fluid being heated in the tubes.
      iii. Do not oversize the control valve or else temperature overshooting and excessive control hunting will result in unstable operation and premature valve/actuator failure.
         1. For University Park campus steam characteristics refer to 33 63 00 STEAM ENERGY DISTRIBUTION.
         2. For buildings served by campus low pressure steam, system pressures can vary seasonally between 5-12 psi, with 5 psi as the winter design condition. Coordinate selection of control valve and heat exchanger accordingly. Review with OPP Engineering Services.
      iv. Maximum Velocity limits: (confirm with manufacturer per application)
         1. Tubeside Nozzle Velocity: 8 fps
         2. Shellside Nozzle Velocity: 4 fps
         3. Shellside Condensate Velocity: 2.5 fps

4. Maximum tube velocity shall not exceed the following, but may be less to keep water pressure drop low.

Material	**Max. Tube Velocity**
Stainless Steel:	10 ft/sec
90-10 Cupronickel:	10 ft/sec
Copper:	6 ft/sec

v. Minimize water pressure drop while maintaining effective heat transfer: select to minimize pumping energy, typically 8 feet (3.5 psi) max.

vi. Fouling factor: Shall be determined based on specific application and local water quality and Professional judgment. Refer to manufacturer's recommendations and/or Standards of Tubular Exchanger Manufacturers Association. Typical listed value for low pressure steam heating medium (approximately 230-250ºF) to recirculated hot water application with "treated boiler feedwater" (temp. greater than 125ºF and velocity over 3 ft/sec) is **0.001** ft^2 ºF/Btu. [Note: This is higher than the previous value in the OPP standard of 0.0005 (the value for distilled water per table from TEMA).]

vii. Refer to Equipment Requirement Piping Connection options to avoid excessive velocity and impingement erosion on the tubes.

viii. Steam Traps: Provide properly sized and installed steam traps for complete condensate drainage. Inadequate drainage of condensate can result in significant loss of capacity and even in mechanical failure.

1. The trap should be sized based on a 0.5 psig differential pressure, assuming 2 psig inlet pressure, 0 psig outlet pressure and a minimum 18" fill leg from the shell outlet to the trap inlet.
2. Allow a minimum **1.5 safety factor** times the anticipated full load capacity for start-up conditions.
3. A float and thermostatic trap is typically the best selection for heat exchanger with modulating temperature control.

ix. Mounting Height: Always allow enough mounting height of heat exchanger to allow gravity drainage of the condensate from the steam trap to a vented

gravity return line or a condensate return pump if gravity return is not feasible. Avoid any lift in condensate return line above trap.

3. Gasketed Plate and Frame type:
    a. Applications include:
        i. Closed Water to water systems with design approaches typically less than 15ºF and small fluctuations of temperatures and pressures. (i.e. - Process Cooling Water, Segregated loops requiring anti-freeze solution).
        ii. Fluid separation between open and closed systems. (Open cooling tower to closed loop condenser water or water-side economizer).
        iii. Heat transfer between systems with fluids that require routine cleaning of heat exchanger surfaces due to fouling conditions.
        iv. Special temperature and/or pressure separation requirements of parts of a system with relatively low pressure and temperature differences and fluctuations.
        v. Specialized industrial or food processes with steam (non-HVAC applications).
    b. Selection Criteria
        i. Minimize water pressure drop while maintaining effective heat transfer: select to minimize pumping energy, typically 8 feet (3.5 psi) max.
        ii. Fouling factor: Shall be determined based on specific application and local water quality and Professional judgment.

4. BRAZED-PLATE HEAT EXCHANGERS
    a. Applications could include:
        i. Closed, very clean systems that would not require routine opening for cleaning of heat exchanger.
        ii. Refrigeration
    b. Review potential application with OPP.

5. Other specialty heat exchangers for special applications: Review with OPP.
    a. Spiral
    b. Helical tube

6. Additional Resources:
    a. ASHRAE Systems and Equipment Handbook: Heat Exchangers
    b. Standards of Tubular Exchanger Manufacturers Association

c. Bell Gossett Article **Steam Control and Condensate Drainage for Heat Exchangers,** http://completewatersystems.com/2011/04/steam-control-and-condensate-drainage-for-heat-exchangers/

D. Related Standards Sections
1. 23 00 01 Owner General Requirements and Design Intent
2. 23 00 10 Systems Selection and Application
3. 23 01 00 OPERATION AND MAINTENANCE OF HVAC SYSTEMS
4. 23 05 01 Mechanical General Requirements
5. 23 05 19 Measuring Instruments for HVAC
6. 23 05 93 Testing, Adjusting, and Balancing for HVAC
7. 23 07 00 HVAC INSULATION
8. 23 21 13 Hydronic Piping
9. 23 22 00 STEAM AND CONDENSATE PIPING AND PUMPS
10. 25 00 00 INTEGRATED AUTOMATION
11. 25 90 00 GUIDE SEQUENCES OF OPERATION

E. Documentation: The Professional shall schedule all heat exchanger selection and performance data and project/application specific requirements on the drawings (not within project specifications). Schedules shall indicate identification tag, system served, location, operation (Duty/Standby or Lead/Lag), type (i.e. end suction, double suction), service fluid (i.e percentage of glycol), entering and leaving temperatures, heat exchange capacity, fouling factor, minimum and maximum flow rates, maximum fluid velocities, minimum rated working pressure, inlet steam pressure, water pressure drops, number of passes, number of plates, manufacturer and model number (basis of design), maximum dimensions, operating weight, options/remarks.
1. It is imperative to define all parameters to optimize selection for efficient heat transfer, achieving low pressure drop, and keeping velocities in range to avoid failures due to erosion.
2. Professional shall follow University Equipment Acronym List and Equipment numbering policy defined in Mechanical Identification in developing equipment tags and schedules.
3. Professional shall carefully review and edit the guideline installation details below, adapting them as needed to achieve application-specific, fully developed details for each project.

Document	Version Date	Description

235700 D01.dwg 235700 D01.pdf	November 9, 2011	Guideline detail: Typical low pressure steam to hot water shell and tube heat exchanger with extended shell and high performance v-ball control valve.

F. Quality Assurance and Uniformity:
   1. All heat exchangers shall be constructed, installed, inspected and tested in accordance with requirements of all Authorities Having Jurisdiction:
      a. Current local Building Codes
      b. PA Dept. of Labor & Industry, Bureau of Occupational and Industrial Safety, Boilers & Unfired Pressure Vessels: Installation and Other Requirements
         i. Boiler and Unfired Pressure Vessel Law (Act 85 of 1998)
            1. Design and Construction
            2. Registration
            3. Inspections
         ii. Boiler and Unfired Pressure Vessel Regulations
            1. 3a.36 Clearances.
            2. 3a.71 Compliance with ASME Code for installations of unfired pressure vessels.
            3. 3a.167 Hot water/steam heat exchangers.

   2. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1. Affix ASME label.
   3. Heat exchangers shall be of U.S. manufacturer.
      a. Provide US steel certification if required by Project. See Exhibit E: Trade Practices Act Contract Clause; and Exhibit F: Steel Products Procurement ACT Contract Clause in 00 00 00 PROCUREMENT AND CONTRACTING REQUIREMENTS , DGS Exhibits A-H
   4. Provide heat exchangers of same type by same manufacturer.
   5. Source Quality Control
      a. For special high pressure applications above typical HVAC working pressure rating (150 psig) hydrostatically test heat exchangers to minimum of one and one-half times pressure rating before shipment.
         i. Heat exchangers will be considered defective if they do not pass tests and inspections.
         ii. Prepare and submit test and inspection reports.

G. Submittals: Documents shall require the following:
    1. Product Data: Include manufacturer's specifications, rated capacities, operating characteristics, gages and finishes of materials, accessories, and furnished specialties.
    2. Shop Drawings: Detailed equipment assemblies including dimensions, weights, required clearances, components, and location and size of each field connection and installation instructions.
        a. Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
        b. Delegated-Design Submittal: If required for seismic restraints - Details and design calculations for seismic restraints for heat exchangers. Calculate requirements for selecting seismic restraints and for designing bases. Signed and sealed by a qualified professional engineer.
    3. Coordination Drawings: Where space constraints dictate careful planning for efficient installation of different components or if coordination is required for installation of products and materials by separate installers include detailed scaled drawings and/or 3-D CAD models, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
        a. Tube-removal space.
        b. Structural members to which heat exchangers will be attached.
    4. Maintenance Data: Include operating, maintenance and repair instructions and spare parts lists.
    5. Source quality-control reports.
    6. Seismic Qualification Certificates: For projects with Seismic requirements, include from manufacturer for heat exchanger, accessories, and components.
    7. Field quality-control test reports.
    8. Sample warranty.
    9. Include all approved submittal data in maintenance manuals; in accordance with requirements of Section 23 01 00 OPERATION AND MAINTENANCE OF HVAC SYSTEMS.

H. WARRANTY
    1. Include manufacturer's standard form in which manufacturer agrees to repair or replace components of heat exchangers that fail under normal use due to defective materials or workmanship within specified minimum warranty period.
        a. Within a period of six months from date of shipment as to those parts which contain perishable elastomers.

b. Within one year from the date all other equipment or part thereof is first placed in use, or two years from the date of shipment, whichever shall be less.

.02 Equipment Requirements

A. SHELL-AND-TUBE HEAT EXCHANGERS

1. General Description: Packaged assembly of outer shell with pipe connections, removable tube bundle, piping connection header, support saddles and specialties. Capacities as scheduled on drawings with permanently affixed nameplate information.
2. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
3. Configuration: U-tube with removable bundle.
4. Shell Materials:
   a. Typical HVAC applications.
      1) Steam to hot water: Steel
      2) Water to water (closed systems): Steel
   b. Consult manufacturer for special applications.
5. Head:
   a. Select material for fluid and service conditions to be resistant to corrosion. Do not use ferrous materials on open systems. **[Cast Iron, Fabricated Steel, Cast Bronze, Stainless Steel – consult with manufacturer for applications]**.
   b. Shall be flanged and bolted to shell.
6. Tubes: Shall be selected to withstand corrosive attack by both fluids in the heat exchanger and to be resistant to impingement erosion. Diameter shall be determined by manufacturer based on service.
   a. (Typical HVAC heating applications -):
      1) Steam to hot water:
         a) **[Copper, 18 ga. Seamless:]** to be used in combination with extended shell with steam inlet beyond end of u-bends so steam does not directly hit tubes.
         b) **[Stainless steel (304), Electric Resistance Welded:]** to be used if extended shell will not fit and steam inlet must be directly over tubes.
      2) Water to water (closed systems): 18 ga. Copper, seamless
   b. Special applications: consult with manufacturer for recommended materials for application. Do not use copper or stainless steel in applications with chlorine such as pool water

heating. Substitute 90/10 CuNi or as otherwise recommended by heat exchanger manufacturer.

7. Tubesheet Materials: The tubesheet, in addition to its mechanical requirements, must be selected to withstand corrosive attack by both fluids in the heat exchanger and must be electro-chemically compatible with the tube and all tube side materials. Low carbon steel tube sheets can include a layer of a higher alloy metal bonded to the surface to provide more effective corrosion resistance with the expense of using the solid alloy. Do not use ferrous materials on open or otherwise high oxygen content systems.
   a. Typical HVAC heating application
      1) Steam to water: **[steel, 90/10 CuNi, stainless steel]**
      2) Water to water: **[steel, 90/10 CuNi, brass]**
   b. Special applications: consult with manufacturer for recommended materials for application
8. Baffles: Select for fluid application and tube material to avoid galvanic corrosion and rust.
   a. Typical HVAC heating application
      1) Steam to water: **[brass or stainless steel]**
      2) Water to water: **brass**
   b. Special applications: consult with manufacturer for recommended materials for application
9. Piping Connections:
   a. For steam applications, the shell inlet connection shall be adequately sized and located to avoid excessive velocity and impingement erosion on the tubes.
      1) Preferred method where space allows is extended shell with steam inlet beyond end of u-bends so steam does not directly hit tubes.
      2) Where confined due to existing space constraints, oversized inlet connection and shell with impingement baffles.
   b. NPS 2" and Smaller: Threaded ends according to ASME B1.20.1.
   c. NPS 2-1/2" and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
10. Support Saddles:
    a. Fabricated of material similar to shell.
    b. Fabricate foot mount with provision for anchoring to support.
    c. For project with seismic restraint requirements as determined by Structural Engineer: Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during seismic event

when heat-exchanger saddles are anchored to building structure.

11. Manufacturers: Subject to compliance with requirements, [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    a. API Heat Transfer Inc.; Basco
    b. Armstrong Pumps, Inc.
    c. Diversified Heat Transfer
    d. ITT Corporation; Bell & Gossett.
    e. TACO Incorporated.
    f. Thrush Company, Inc.

B. GASKETED-PLATE HEAT EXCHANGERS

1. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.
2. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
3. Frame:
    a. Capacity to accommodate a minimum of 10 percent additional plates.
    b. Painted carbon steel with provisions for anchoring to support.
4. Top and Bottom Carrying and Guide Bars: stainless steel.
    a. For project with seismic restraint requirements as determined by Structural Engineer: Fabricate attachment of heat-exchanger carrying and guide bars with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger carrying and guide bars are anchored to building structure.
5. End-Plate Material: Epoxy painted carbon steel.
6. Tie Rods and Nuts: Steel or stainless steel.
7. Plate Material: Designer shall consult with heat exchanger manufacturer to select the most effective material and thickness for each application to achieve the lowest life cycle cost.
    a. Typically stainless steel **[304 or 316]** for most general HVAC applications.
8. Gasket Materials: Gaskets shall be clipped onto the plates. **Glued gaskets are not acceptable.**
    a. Nitrile butyl rubber (NBR) gaskets: for applications up to 230°F.
    b. Ethylene-Propylene Diene Monomer (EPDM) gaskets: for applications up to 320°F.
9. Piping Connections:

a. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
b. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

10. Accessories:
    a. Enclose plates in solid aluminum removable shroud.
    b. Drip Pans: Provide Stainless Steel pans under footprint of heat exchanger to contain leakage on start-up or shut down, gasket failure, or condensation.
11. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    a. Alfa Laval Inc.
    b. API Heat Transfer Inc.
    c. APV; a brand of SPX Corporation.
    d. Armstrong Pumps, Inc.
    e. Diversified Heat Transfer
    f. ITT Corporation; Bell & Gossett.
    g. Mueller, Paul, Company.
    h. TACO Incorporated.
    i. Tranter, Inc.

C. BRAZED-PLATE HEAT EXCHANGERS
1. Configuration: Brazed assembly consisting of embossed or pressed stainless-steel plates brazed together and two end plates, one with threaded nozzles and one with pattern-embossed plates.
2. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
3. End-Plate Material: Type 316 stainless steel.
4. Nozzles: Type 316 stainless steel.
5. Plate Material: Type 316 stainless steel.
6. Brazing Material: Copper.
7. Manufacturers: Subject to compliance with requirements, [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
    a. Alfa Laval Inc.
    b. API Heat Transfer Inc.
    c. APV; a brand of SPX Corporation.
    d. Armstrong Pumps, Inc.
    e. Diversified Heat Transfer
    f. GEA PHE Systems North America Inc.
    g. ITT Corporation; Bell & Gossett.
    h. Mueller, Paul, Company.

i. Tranter, Inc.

.03 Execution

A. Installation
   1. General: Install heat exchangers and accessories in strict accordance with the manufacturer's requirements for maintaining optimum performance and serviceability.
      a. Maintain manufacturer's and University recommended clearances for tube removal, service, and maintenance.
      b. Mount units at height that are serviceable without the need for ladders or scaffolding.
   2. Structural Mounting: Structural support must be adequate so that exchangers will not settle and cause strains on piping connections.
      a. Mount shell and tube heat exchangers on elevated support legs, which in turn shall be anchored to housekeeping pad with anchor bolts. In general, avoid suspending heat exchangers from piping or structure above. Install shell-and-tube heat exchangers on saddle supports. One end of the shell fasteners shall be left loose to allow proper expansion compensation of the shell.
      b. Mount frame of gasketed-plate heat exchangers on base anchored to housekeeping pad with anchor bolts.
      c. Install brazed-plate heat exchanger on custom-designed supports anchored to structure.
      d. In general, concrete housekeeping pads shall be at least 4 in. thick and 6 in. wider on each side than the heat exchanger support footprint. Concrete work shall comply with requirements in Division 03 - Concrete.
   3. Hydronic Piping and Specialties: Comply with requirements for piping specified in 23 21 13 Hydronic Piping. Drawings shall be coordinated to indicate general arrangement of piping, fittings, and specialties.
      a. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers. Unions shall be installed at final connections at right angles to allow the least amount of pipe dismantling for ease of repair and replacement.
      b. The manufacturer’s intended flow path of each fluid on both sides of a heat exchanger design shall be carefully followed. Failure to connect to the correct inlet and outlet connections may reduce performance.
      c. All piping shall be independently supported so that no strain is imposed on the heat exchanger connections.

d. Install flexible pipe connectors to isolate exchanger from any external vibrations that can cause fatigue failures within the heat exchanger.
e. Install line-sized, low pressure drop shutoff valves (typically butterfly) in the entering and leaving piping of each exchanger to permit servicing without draining the system.
f. Install long-tapered reducers and increasers to smoothly transition the pipe size and connection flanges with minimum pressure drop. Abrupt transitions, bushings and reducing flanges are not permissible.
g. Install relief valves on heat exchanger heated-fluid connection and install drain piping from relief valves, full size of valve connection, to floor drain. Avoid creating tripping hazards.
h. Piping shall be arranged so it can be easily vented. Provide an air vent at high points and a hose end drain valve at the low points of water piping connections. Install hose end drain valve to drain shell.
i. Drip pans made of stainless steel shall be installed under plate heat exchangers to contain leakage on start-up or shut down, gasket failure, or condensation. Provide ¾" drain connection, piped to nearest floor drain.

4. Steam Piping and Accessories: Comply with requirements for steam and condensate piping specified in 23 22 00 STEAM AND CONDENSATE PIPING AND PUMPS.
    a. Steam Inlet:
        i. Install steam isolation valve to isolate assembly from main. Install pressure gauge assembly on main side of isolation valve.
        ii. Install fine mesh steam strainer downstream of isolation valve and ahead of steam separator, **with screen pocket installed horizontally** to avoid forming condensate pocket.
        iii. Ensure only dry steam enters the control valve and heat exchanger inlet to avoid water hammer or damaging tubes due to wet steam impingement.
            A. Install end of main drip trap assembly on bottom of steam supply pipe. Install top takeoff on steam supply pipe to control valve. Or
            B. Install a general purpose baffle type moisture separator (made of ductile/SG iron) with drip trap assembly at low point immediately ahead of control valve.
        iv. Install properly sized temperature control valve assembly with unions.

A. For steam applications use a high-performance, stainless steel, v-ball control valve with equal percentage control characteristic with minimum 100:1 rangeability. Refer to BAS Guide Specification in 25 00 00 INTEGRATED AUTOMATION.

v. Install pressure gauge assembly downstream of control valve prior to inlet connection.

b. Condensate Outlet:

i. The heat exchanger shall be pitched slightly (minimum 1/16" per foot) toward the condensate drain connection to ensure good drainage.

ii. For modulating steam supply, install vacuum breaker at heat-exchanger steam inlet connection or on shell. The vacuum breaker shall be mounted on a vertical pipe a minimum of 8" above the tapping to provide a cooling leg to protect vacuum breaker from dirt and extreme temperatures.

iii. Provide a minimum 18" fill leg to trap inlet, with flushable dirt leg, terminating with hose end drain valve below level of trap inlet.

iv. Install strainer with drain valve ahead of steam trap.

v. Install a shut off valve between strainer and trap.

vi. Install properly sized steam traps according to manufacturer's instructions for complete condensate drainage so condensate never backs up in heat exchanger. Include unions to allow trap service or replacement.

vii. Install a check valve and shut off valve to isolate runout assembly from condensate return main.

viii. Return line shall be pitched from trap discharge with no lift to gravity condensate return or to vented condensate return unit if gravity system is unavailable.

5. Measuring Instruments: Comply with requirements of 23 05 19 Measuring Instruments for HVAC.
   a. Install a single pressure gauge assembly with ¼" ball valves and interconnecting piping from the entering and leaving sides of each hydronic system in order that each pressure and/or difference can be observed from a single gauge.
   b. Install pressure gauge assemblies at steam main and after control valve.
   c. Install thermowells and thermometers at each hydronic inlet and outlet, located as near to unit connections as possible.
6. Install metal shroud over installed gasketed-plate heat exchangers according to manufacturer's written instructions.

7. Insulation: Insulate assembly to comply with insulation thickness and performance prescribed by University's High Performance Design Standard (ASHRAE 189.1) and other requirements in 23 07 00 HVAC INSULATION.
    a. Provide removable insulation sections to cover parts of equipment that must be accessed periodically for maintenance (i.e. – tube heads, strainers, vent/drain plugs or valves, p/t ports) without damaging insulation or compromising vapor barrier. Include covers, fasteners, flanges, frames and accessories.
    b. Insulation on systems operating below ambient dew point (such as chilled water) shall be insulated with closed cell foam with all joints and penetrations completely sealed to maintain vapor barrier.
    c. Keep nameplate information uncovered (heating systems) or easily accessible (cold systems).
8. Identification: Provide mechanical identification per University Standards, 23 05 01.06 Mechanical Identification

B. Start-up/Commissioning
1. Hydronic System Balancing;
    a. For general testing, adjusting and balancing requirements, refer to 23 05 93 Testing, Adjusting, and Balancing for HVAC.
    b. Heat Exchanger TAB data:
        i. Identification/Number, Service, Location
        ii. Manufacturer, Model number, Serial Number
        iii. Primary Source fluid entering conditions (temperature / pressure), design and actual
        iv. Primary source fluid leaving conditions (temperature / pressure), design and actual
        v. Primary flow rate, design and actual
        vi. Primary pressure drop, design and actual
        vii. Secondary entering and leaving conditions (temperature and pressure), design and actual
        viii. Secondary flow, design and actual
        ix. Total heat transferred: at design flow conditions and at peak control valve output.
        x. Secondary water pressure drop, design and actual
        xi. Relief valve(s), size, rated capacity, pressure setting.

C. FIELD QUALITY CONTROL
1. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
    a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
    b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

c. Prepare and submit test and inspection reports.
d. Heat exchanger will be considered defective if it does not pass tests and inspections.

D. CLEANING: After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

END of revision

Update Commentary:

Section was updated primarily for the following reasons:

1) *To follow common industry practice to apply shell and tube heat exchangers on steam to hot water applications in lieu of gasketed plate and frame.*
2) *To expand section into three parts for more comprehensive General, Product and Installation requirements.*