Shell & Tube Heat Exchanger

Operation

&

Maintenance Manual

PRE-heat INC.
PACKAGED RECOVERY EQUIPMENT
Industrial Air to Air Heat Exchangers

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General:
The PRE-heat, Inc. shell & tube heat exchanger is designed to transfer energy from a hot stream to a colder stream without allowing the two streams to mix. This is accomplished when the heat transfer tubes are assembled as a fully welded fabrication.

Pre-heat, Inc. also uses variable tube diameter, length, and thickness to build the heat exchanger for your application. These variables allow us to meet your requirements for heat transfer effectiveness and pressure drop.

PRE-heat, Inc. has developed heat transfer programs for all our products. These programs have been field checked showing that the calculated performance matches that of a typical installation.

Operating Temperature:
The 409 stainless steel shell & tube heat exchanger is used when recovering energy from exhaust streams with a limited hot inlet temperature of up to 700 F. Differential pressure across the tubes is also limited to 20 inches water gauge.

The 304L stainless steel shell & tube heat exchanger is used when recovering energy from exhaust streams with hot inlet temperatures up to 1,300 F. Differential pressure across the tubes can reach as high as 27.7 inches water gauge.

The 316L stainless steel shell & tube heat exchanger is used when air stream chemistry requires an up grade over 304L SS. Hot inlet temperature is limited to 1,400 F. and differential pressure at 27.7 inches water gauge.

The 309S and 310S stainless steel units are for operation when hot inlet temperatures are 1,500 F. to 1,600 F. and differential pressure up to 27.7 inches water gauge.

Important Note:
Units are to be heated up and cooled down at a maximum temperature change of 50 degrees Fahrenheit per minute.

Receiving the heat exchanger:
Equipment received should be checked for compliance with the original order. Immediately upon receiving shipment, the unit should be inspected for evidence of damage from handling or transportation. If damage is evident, a claim should immediately be filed with the transportation - shipping company. For lifting information see next paragraph.

Lifting and Handling the heat exchanger:
The heat exchanger can be moved or lifted with a forklift truck or crane of proper size for the weight and dimensions of the heat exchanger. Avoid damaging the heat transfer tubes, casing and insulation with cladding. The lift load should be evenly distributed over a minimum of two lifting points on the heat exchanger exterior. This may require the use of spreader bars during crane lifts to lift at 90°, and fork extensions on forklift trucks. DO NOT rotate the heat exchanger unless specifically directed by PR-heat at to direction of rotation. This can cause damage to the unit as it was designed to be supported in certain orientations. In some cases a lifting drawing would be provided.

Storage of the heat exchanger:
If the unit is to be stored indoors prior to its installation, we recommend that the shipping covers remain in place and the unit left on its shipping pallet. When stored outdoors, we recommend the above and covering the unit with a weatherproof tarp. If the unit is shrink wrapped to not remove coverings until ready for installation.

Installation Considerations:
The shell & tube type heat exchanger can be installed indoors or outdoors. We recommend that you allow sufficient room on all sides of the heat exchanger for any maintenance considerations or equipment inspections.

The shell & tube type heat exchanger can be installed with the tubes in the vertical or horizontal position. When installed with the tubes in the vertical position, we suggest that the hot stream enter at the top of the unit and exit at the bottom. This will allow drainage of any materials that condense as they pass through the heat exchanger tubes. When the unit is installed in the horizontal position, we recommend that the unit be pitched down in the direction of airflow of the condensing air stream. All liquid drainage is handled in the attached ductwork unless the heat exchanger is specifically designed for internal drainage. Drainpipe size is determined by the expected volume of water to be removed from the system. Standards for sizing gravity drain piping is as follows:

G P M:	**MINIMUM PIPE SIZE (at heat exchanger):**
0 to 11	1” Pipe
12 to 15	1.5” Pipe
16 to 25	2” Pipe
26 to 60	2.5” Pipe
61 to 90	3” Pipe
91 to 120	4” Pipe

(Above, limited to a maximum of 100 equivalent feet of pipe).

The gravity drain system with an atmospheric vent, trap depth is determined by the system’s static pressure measured at the location of drainpipe connection. The water column of the trap is 7 inches + the static pressure in inches water gage. Design the pipe trap with fittings that will allow cleaning of the trap. Remember to fill the trap with water prior to starting the system fans

INSTALLATION NOTE: Wash systems require the drain piping to be sized to handle the gallons per minute of wash fluid flowing through the heat exchanger.

INSTALLATION NOTE: Cold weather operation requires all liquid pipe systems to be heat taped and insulated to avoid freeze-up.

Flange Connections:
The gasket material for assembling flange connections should be compatible with the air stream chemistry and temperature. Flanges are bolted together using both flat and lock washers. We recommend checking the bolted connections during regular maintenance.

Ductwork and Transitions:
The effectiveness of the shell & tube type heat exchanger can be adversely affected by poor airflow distribution. Inlet and outlet transition design should produce an even distribution of the air stream across the entire inlet and outlet face of the heat exchanger. When space limits transition design or when elbows are attached to the heat exchanger inlet, turning vanes turning vanes, diverters, and perf plates should be used to evenly distribute the air stream. Be sure to check system pressure drops are good for fan sizing.

Large heat exchanger or multiple heat exchanger installations:
Design plenums for even distribution of air across the inlet and outlet connection. The use of turning vanes, diverters, and perf plates should be used to evenly distribute the air stream. Be sure to check system pressure drops are good for fan sizing.

System expansion considerations:
Varying designs of expansion joints are available for purchase from PRE-heat, Inc. These expansion joints are available with different mounting designs. The expansion joints are designed to protect the heat exchanger by allowing the unit to grow as the metal temperature increases. System expansion joints should be installed in the ductwork and piping to compensate for its expansion when operation is at or above 350 F. PRE-heat, Inc. recommends that at least one end of the heat exchanger be allowed to move in a controlled method to relieve expansion

Heat exchanger vertical loading limits:
Contact PRE-heat Inc. for heat exchanger vertical load limitations if that information is not present on the engineering drawings. Typical heat exchanger design limits vertical loading to a maximum of 500 LB on the heat exchanger flange. Optional structural supports can be added to the heat exchanger at the factory for vertical loads above 500 LB.

Insulation:
PRE-heat, Inc. recommends internal insulation on most shell & tube type heat exchangers to keep heat losses to a minimum and provide safety to personal in the vicinity of the installation.

Temperature control:
Damper systems can be added to the hot gas stream or the cold air stream to control temperature. The design and material of construction will be compatible with the air stream chemistry and temperature. These options are available for purchase from PRE-heat Inc.

Removable access doors:
Optional access doors are used on heat exchangers that are installed on exhaust streams that will result in frequent cleaning maintenance or units that require frequent internal inspection. The access doors are fastened to a flange that is part of the heat exchanger. Gaskets are used to seal this connection. Check the gasket and replace when necessary before reattaching the removable access door. PRE-heat, Inc. also provides optional hinged access doors

Wash systems:
Optional wash systems are available that include wash headers, solenoid valves and controls. Utility requirements for these wash systems are listed on separate engineering drawings. Cleaning solutions are selected at the discretion of the user and should be compatible with the equipment's material of construction.

Heat Exchanger Startup:
Initial system startup should have all dampers open, fans and blowers set for their lowest volume of operation and hot gas temperature at its minimum temperature setting. The start up engineer should check all parts of the system to ensure that air flowing through the heat exchanger matches the unit's design. Tubular heat exchangers are designed to have 1 air stream passing through the tubes and the other air stream passing over the tubes on the shell side. All heat exchangers are designed to have a counter flow direction between air streams unless otherwise specified from PRE-heat engineering during the design phase.

When the initial checks are completed, begin ramping up of the cooling system air volumes first to meet process specifications. Then begin ramping up hot system air per PRE-heat specified 50 degree per minute or less. When the system has reached its normal operating load and temperature, measure the temperature at the hot (exhaust) inlet and outlet. Measure the cold (air) stream temperature at the inlet and outlet. Measure the pressure drop on the hot and cold sides of the unit. Finally measure the hot exhaust volume and the cold air volume. Compare the measurements to those listed on the equipment design worksheet / calculation page. Report any discrepancies to PRE-heat, Inc. for resolution.

When turning down the system follow the initial system startup step in reverse. Begin by ramping down the hot air stream per PRE-heat specified 50 degrees per minute or less. Once the hot air stream is ramped down then turn down the cold air stream to desired volume or off.

Important Note: Units are to be heated up and cooled down at a maximum temperature change of 50 degrees Fahrenheit per minute.

Important Note: NEVER run the heat exchanger with ZERO cooling air when hot air system is running at any temperature. If the exchanger is going into an idle mode, the cooling air volume NEEDS to remain 25% higher than the hot air volume to keep the unit from over temping.

Seal air system operations & limits:
1. Seal air pressure is determined by the initial blower static pressure and leak rate. Actual pressure is based on the initial starting pressure and is a field measurement.

2. Seal air pressure must be set no less than +1/2" w.c. greater than the highest system pressure.

3. Check the seal air system if there is a sudden loss of seal air pressure i.e. 10% or more loss of pressure occurs during normal operation. Contact PRE-heat if there is an increase in pressure loss greater than listed.

Troubleshooting:
1. If heat exchanger slowly drops in efficiency check tube side and shell side tubes for fouling. When fouling occurs, then cool down heat exchanger and clean tubes with compressed air. If the fouling is severe use a commercially available tube cleaning brush to clean tubes inside. You can also contract a professional boiler vessel service to inspect and clean the tubes on an annual basis.

2. If seal air pressure slowly drops or suddenly drops check seal air system for leaks or blower problems.

    - Check seal air damper for the correct position.
    - Check seal air blower for proper operation.

- Clean filter and intake screen
- Check lower air seal tube sheet for detached seal air couplings.
- Check lower air seal tube sheet expansion joint for rupture.

3. If a by-pass damper is included and should bind then:
   - Remove heat exchanger access door and inspect rotation of the by-pass damper on its bearings.
   - Inspect each by-pass bearing for wear and check the rotation of each bearing in its casing.

Repair & Maintenance:
In case of extreme amounts of particulate, the heat exchanger may foul up completely. In the case that manual cleaning has to be done, it is recommended to proceed as follows.

- Cool down the plant until it is safe to enter the heat exchanger tower.
- Please note that the temperature readings from the thermocouples only indicate the temperature of the gas (air) in the heat exchanger tower and may also be influenced in case that they are positioned next to an open door. The insulation material and the heat exchanger units may still be hot.
- Prepare all tools adequate for cleaning. We recommend using a Good way RAM series of heat exchanger cleaners www.goodway.com
- Enter heat exchanger from side access door
- If tube(s) need to be replaced contact PRE-heat Inc. for repairs.
- Seal air blower is a purchased part, if repairs are needed return the blower to your Cincinnati blower or New York Blower representative.
- If by-pass damper bearing(s) need to be serviced, disassemble by-pass damper per the included by-pass damper drawing. Service bearing(s) then reassemble and place heat exchanger back into service.

Expected PM Schedule:
Listed for a 6-month rotating PM schedule.

- Visual inspection of the by-pass damper bearing(s), check for wear.
- Visual inspection of the by-pass damper check damper seat for dirt build up.
- Check seal air blower motor for bearing(s) wear.
- Visual inspection of the top seal sheet tube sheet (yearly).
- Visual inspection of the seal air sheet (bi annual).
- Visual inspection of the shell side tubes as viewed through the by-pass access doors (yearly).

Expected PM Schedule continued: Recording Measurement
The following measurement are to be recorded during the schedule PM to ensure the heat exchanger is functioning properly.

- Hot stream inlet temperature and static pressure
- Hot stream outlet temperature and static pressure
- Hot stream volume (ACFM or SCFM)

- Cold stream inlet temperature and static pressure
- Cold stream outlet temperature and static pressure
- Cold stream volume (ACFM or SCFM)

Using the above information, updated measurements and equipment inspection is used for determining when maintenance is required.

Conclusion:

- Failure to follow the instruction of this O&M manual could result in decreased longevity in the unit and possibly failure of the heat exchanger design. See Warranty information below.
- If there are any questions or concerns about the heat exchanger information listed in this O&M manual, please contact a PRE-heat representative for clarification.
- If there are any questions or concerns regarding the function or operation of this heat exchanger, please contact a PRE-heat representative.

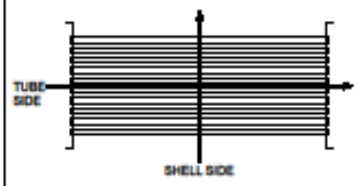
PRE-heat Contact information:
421 S. Business Park Drive
Oostburg WI 53070
Phone: 920-564-6876
Contact: Sales or Engineering representative.

Work Safety Hints

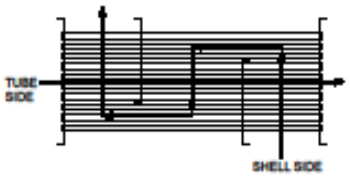
The following work safety tips are especially to be heeded:

- The heat exchangers described in this manual and its components are designed and built according to the latest technological developments. Yet this plant can be dangerous if used improperly by untrained personnel or used for other purposes than those designated.
- Each person in the operating company who is involved with the assembly, disassembly and reassembly, start-up, operation and maintenance (inspection, maintenance, repairs) of the plant or parts of the plant must have read and understood the entire operating manual, particularly the chapters on safety. It is recommended that the operator of the plant have this confirmed in writing. All O & M documentation for applicable equipment components has been included in this manual.
- Before working on parts of the heat exchanger system the operator is responsible for the plant has to be informed. The personnel intending to work on the heat exchanger system have to be informed about the current status of the heat exchanger system (temperatures, pressures, other ongoing work etc.) and of the risks that might be involved in the work. The heat exchanger operator has to be informed when and how the work is completed.
- The heat exchangers are to be used solely for the application defined in this operating manual. Any application beyond this is considered to be not in accordance with regulations. The manufacturer is not liable for damages resulting from usage not in accordance with regulations; the user alone carries this risk.
- Observance of the conditions for assembly, disassembly and re-assembly, start-up, operation and maintenance stipulated by the manufacturer is also a part of usage according to regulations.
- The heat exchanger system may be operated, maintained and repaired only by authorized, trained and instructed personnel. This personnel must have received special instructions with regard to possible dangers.
- Refrain from all working methods which reduce the safety of the heat exchanger system.
- It is also the responsibility of the operator to make sure that no unauthorized people work on the heat exchanger system.
- The operator is obligated to immediately report any changes in the heat exchanger which have an influence on safety.
- The operator is obligated to always operate the heat exchanger system only when it is in design working condition and corresponds to safety regulations.
- By means of the corresponding instructions and checks, the user must ensure that the heat exchanger system is kept clean and orderly.
- Should surface temperatures exceed 158 °F (~70 °C), then the operator is obligated to put a clearly visible sign on or near the hot parts of the installed and operational heat exchanger system warning of the danger of burning
- Self-determined modifications and changes which influence the safety of the heat exchanger system are not allowed.
- All work inside the hot parts of the heat exchanger system may only be done when the plant is cold and at a standstill. All other work must only be done in accordance with the safety regulations for the components.

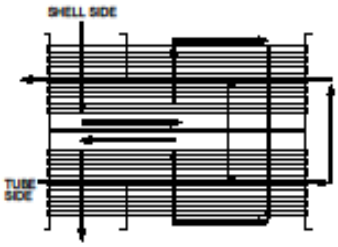
HORIZONTAL UNIT CONFIGURATIONS



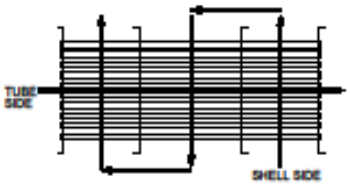
HORIZONTAL CROSS-FLOW CONFIGURATION



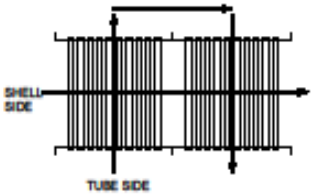
MULTIPLE PASS CONFIGURATION
WITH INTERNAL SHELL SIDE TURNS



MULTIPLE TUBE PASS WITH
MULTIPLE SHELL PASS CONFIGURATION



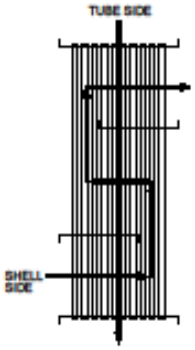
MULTIPLE PASS CONFIGURATION
WITH EXTERNAL SHELL SIDE TURNS



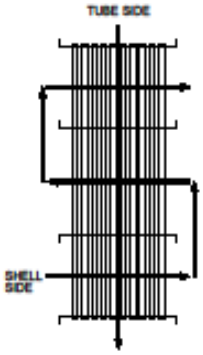
MULTIPLE TUBE PASS WITH
MULTIPLE CROSS FLOW CONFIGURATION
WITH EXTERNAL TUBE SIDE TURN

VERTICAL UNIT CONFIGURATIONS

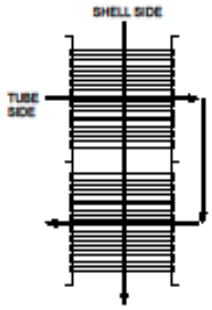
VERTICAL CROSS-FLOW
CONFIGURATION



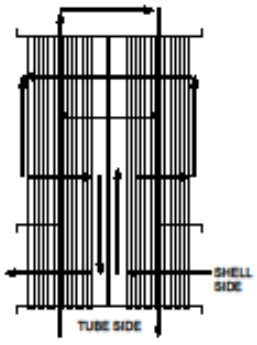
VERTICAL MULTIPLE PASS
CONFIGURATION WITH
INTERNAL SHELL SIDE TURNS



MULTIPLE PASS CONFIGURATION
WITH EXTERNAL SHELL SIDE TURNS



MULTIPLE TUBE PASS WITH
MULTIPLE CROSS FLOW CONFIGURATION
WITH EXTERNAL TUBE SIDE TURN



MULTIPLE TUBE PASS WITH
MULTIPLE SHELL PASS CONFIGURATION