



T. H. Industrial Solutions

www.th-is.ca

**PLATE & FRAME / SHELL & TUBE
HEAT EXCHANGERS
FACT MANUAL**



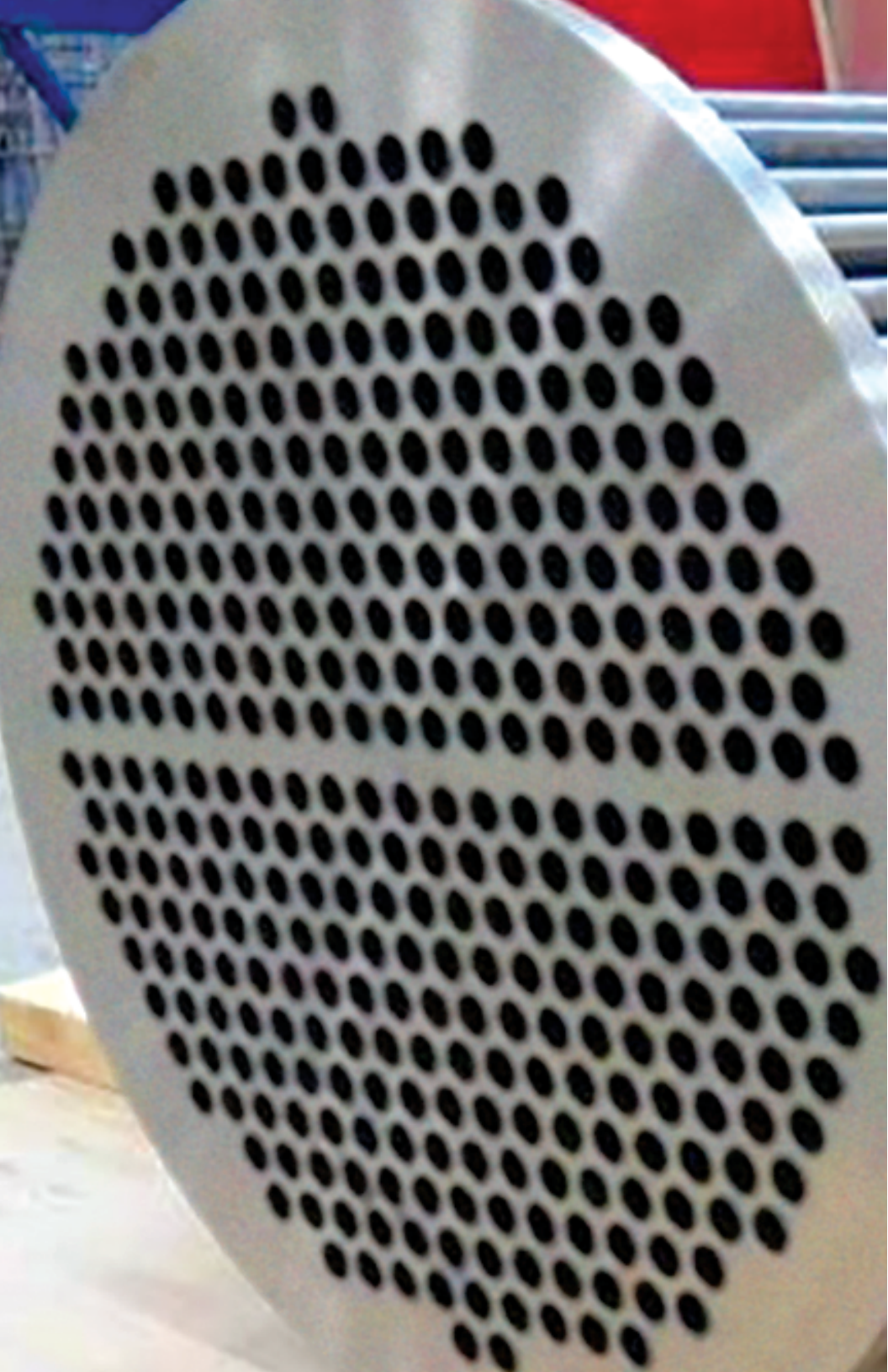
T. H. Industrial Solutions

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**An essential risk assessment
reference guide for
Maintenance Supervisors,
Property and Plant Managers**



Proudly Canadian



**“FAILING TO PLAN
IS PLANNING TO FAIL”**

How long can you be without hot water,
air conditioning and heating?

The consequences of heating/cooling
heat exchanger failure are critical!

The challenges facing building and
plant managers are vast and
increasingly complex.

Energy costs and lost production
comprise a significant component of
operational expenses.

In addition, identifying potential issues
with thermal transfer equipment
prior to a failure is essential.

Greg David
President & CEO

HEAT EXCHANGER APPLICATIONS

Food & Beverage



Automotive



Nuclear



HVAC



Dairy



Pulp & Paper



Power



Breweries



Steel



Marine



Sugar Refineries



Pharmaceutical



Petroleum/Chemical



Bioenergy



Mining

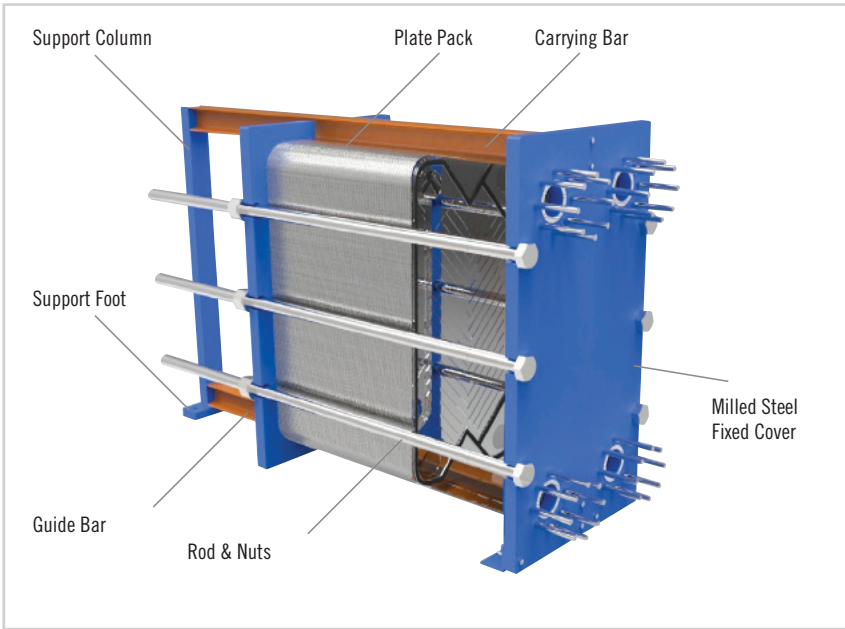


PLATE & FRAME HEAT EXCHANGERS



PLATE & FRAME HEAT EXCHANGERS (PHE)

The main components of a Plate & Frame Heat Exchanger consist of the following:



The most common material for the plates is 304 or 316 stainless steel in a (.4mm), (.5mm) or (.6mm) thickness. Gaskets type depends on the operating application, typically Buna (NBR/Nitrile), EPDM or Viton elastomer gaskets are usually specified.

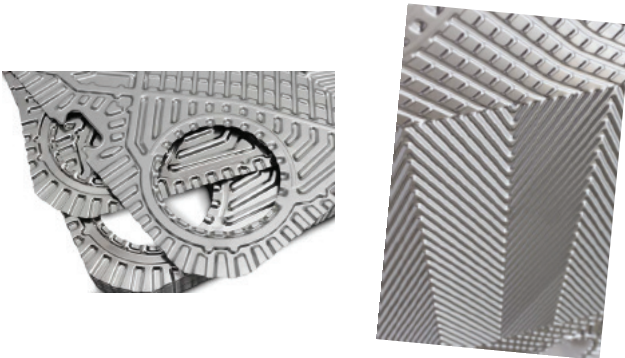


PLATE & FRAME HEAT EXCHANGERS (PHE)

The main components of a Plate

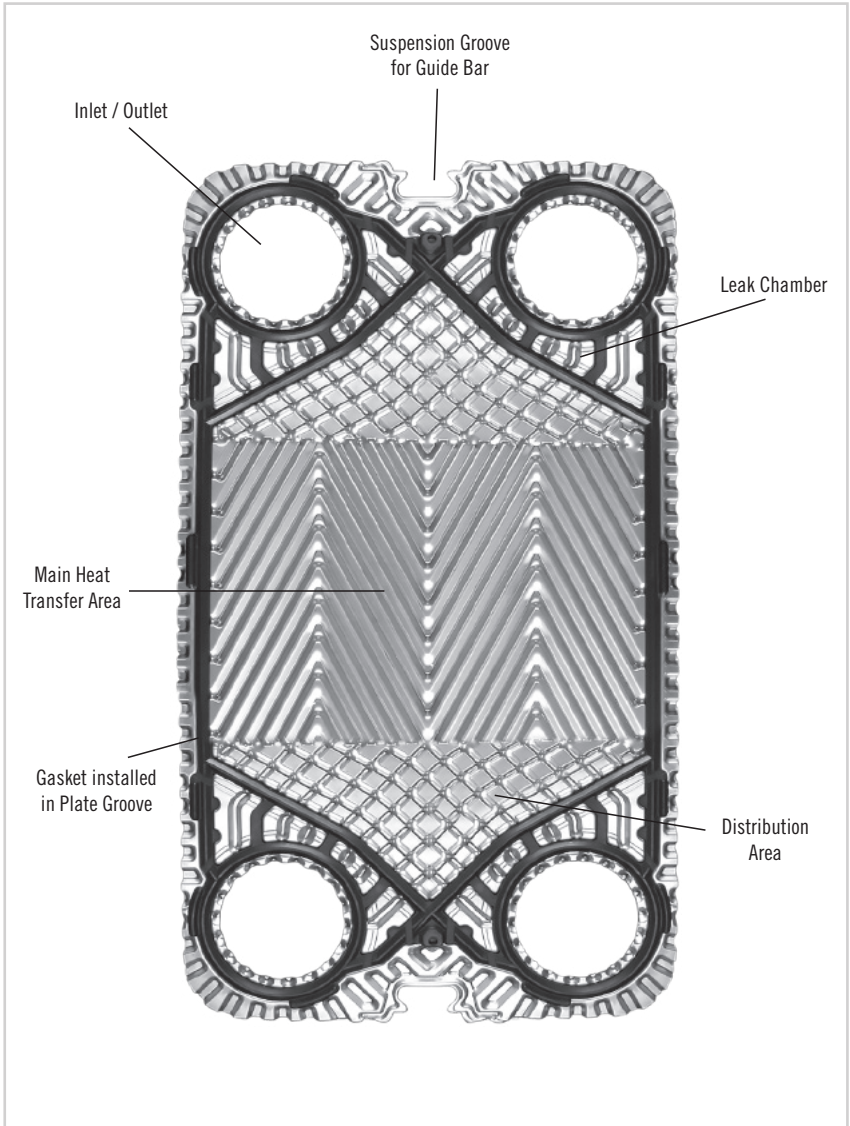


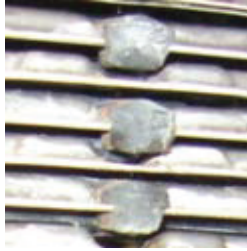
PLATE INSTALLATION

When plates are installed correctly they will form a honeycomb pattern and if glue-less gaskets (Clip, Ball) are used the tabs will be aligned.

Clip



Ball



Glue (no tabs)



Honeycomb Pattern

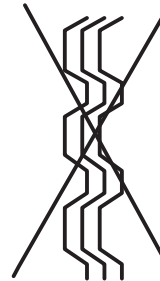
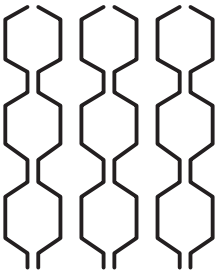
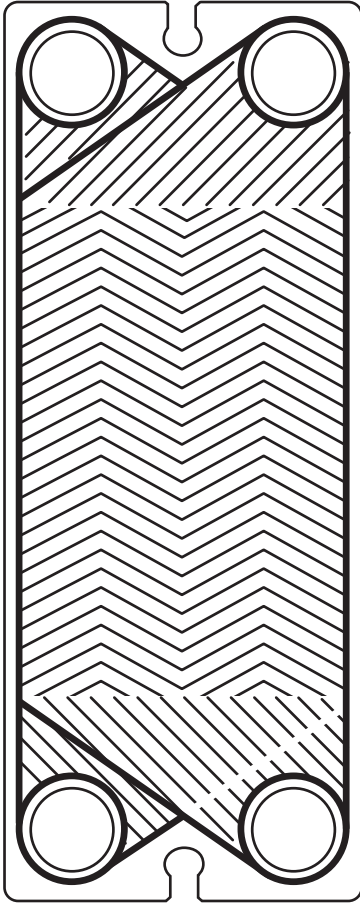
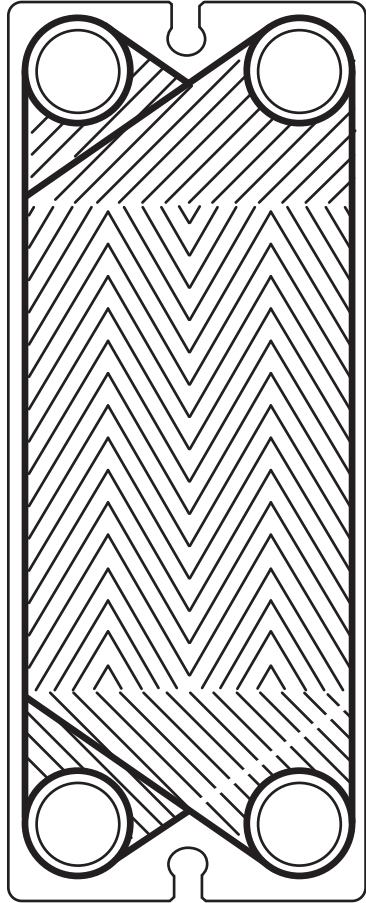


PLATE PATTERN



HIGH THETA PLATE PATTERN

- High turbulent flow
- High heat transfer coefficient
- Perfect temperature approach
- High pressure drop

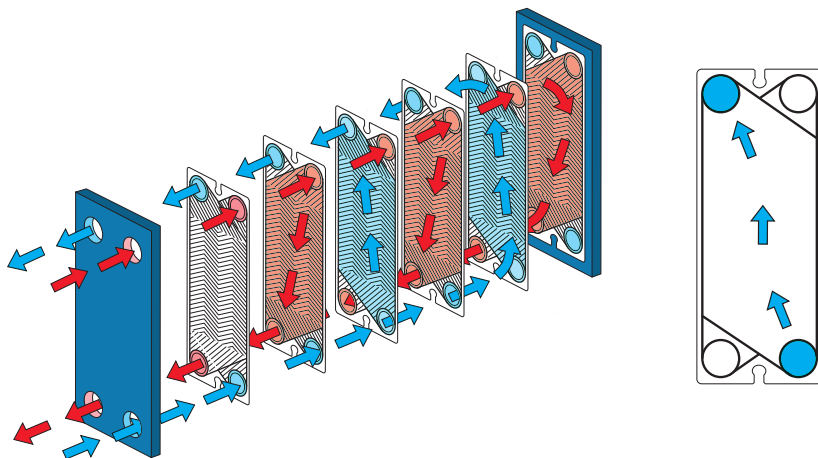


LOW THETA PLATE PATTERN

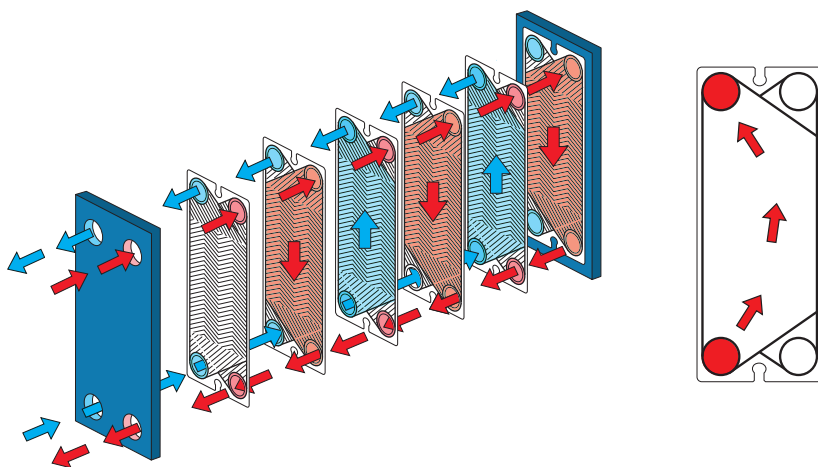
- Low turbulent flow
- Low heat transfer coefficient
- High temperature approach
- Low pressure drop

DIAGONAL VS PARALLEL FLOW

DIAGONAL FLOW

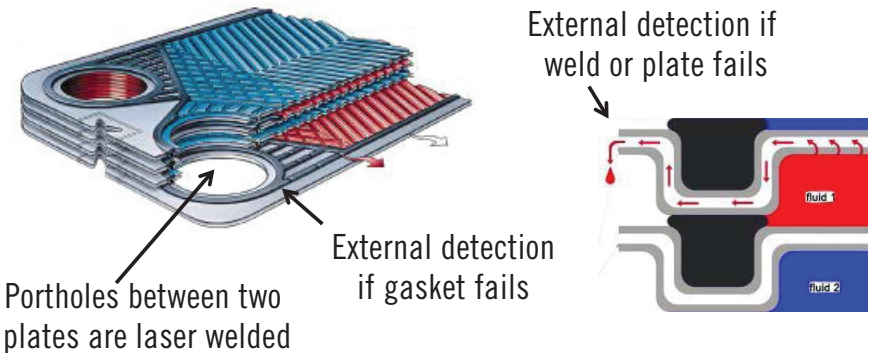


PARALLEL FLOW



DOUBLE-WALL PLATES

The Double-Wall Plate consists of two identical plates laser welded together leaving a thin air gap between the plates acting as a safety zone in case either of the plates were to fail. In the case of failure, one of the two fluids would leak through the first plate preventing it from going any further due to the air gap and the second plate. The leak would be seen externally on the heat exchanger. This design offers maximum safety against cross contamination.



EXAMPLES OF DOUBLE-WALL PLATE HEAT EXCHANGER APPLICATIONS:

Transformer Oil Cooling – Water / Oil mixture can result in severe damage to transformer

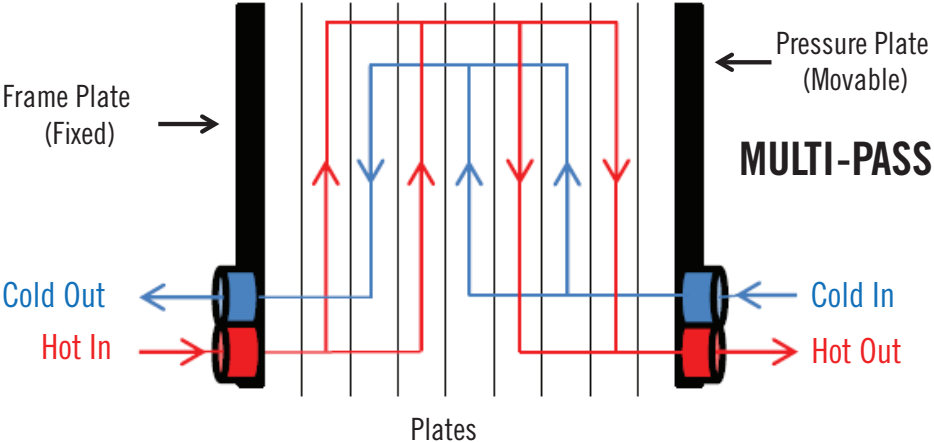
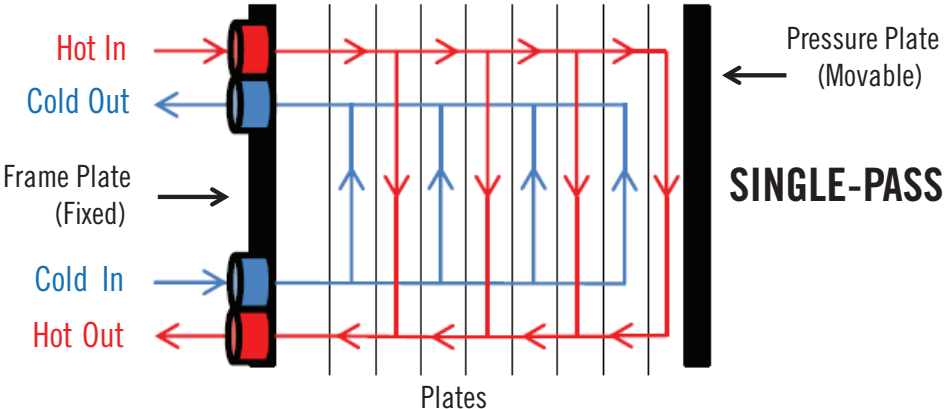
Chemical Processes – Intermixing can cause contamination, explosions, chemical reactions, corrosion

Potable Water Heating – Distributing heat generated in a centralized location for residential and commercial heating requirements such as space heating and water heating, intermixing could scald, pollute tap water

THE ONTARIO BUILDING CODE | CONNECTION OF SYSTEMS* 7.6.2.1. Connection of Systems

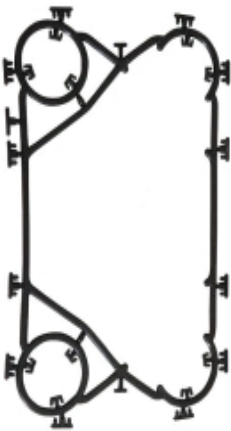
- (1) Connections to *potable water systems* shall be designed and installed so that *non-potable* water or substances that may render the water *non-potable* cannot enter the system.
- (2) No connection shall be made between a *potable water system* supplied with water from a *drinking water system* and any other *potable water system* without the consent of the *water purveyor*.

SINGLE-PASS AND MULTI-PASS APPLICATIONS

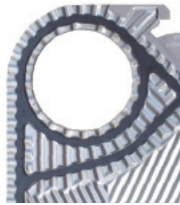


TYPICAL GASKET TYPES

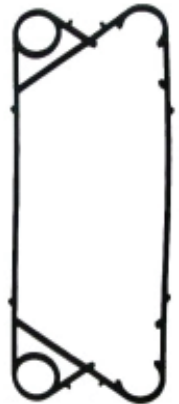
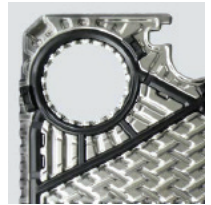
Clip



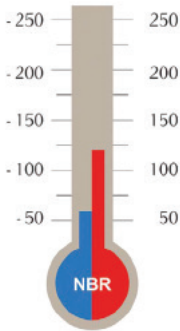
Glue



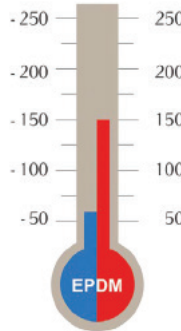
Ball



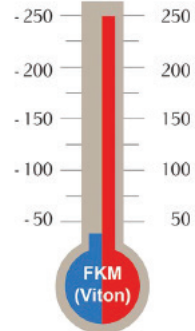
BUNA (NBR/NITRILE), EPDM OR VITON MATERIALS ARE THE MOST COMMON ELASTOMER GASKETS DEPENDING ON THE OPERATING APPLICATION.



Food Grade



Standard Grade



Aggressive Chemical Compounds

Changes in Gaskets:

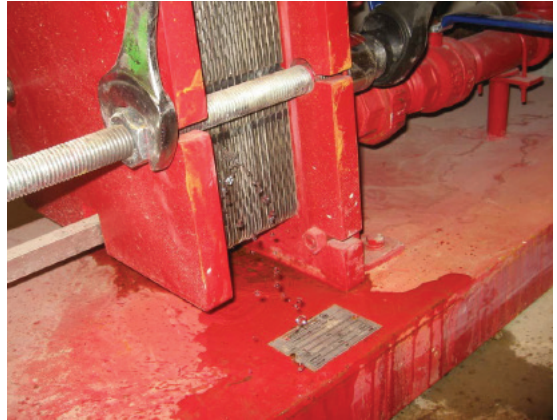
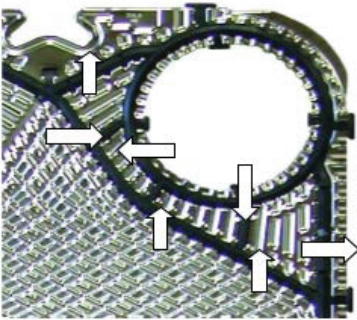
- Time – Relaxes
- Temperature – Deteriorates
- Oxidizing Agents – Hardens
- Swelling – Chemical Absorption

Gaskets Material Depends on:

- Fluids Used
- Temperature and Pressure



GASKETS ARE DESIGNED WITH VENTING PORTS, THESE PORTS PREVENT CROSS CONTAMINATION INSIDE THE HEAT EXCHANGER. WHEN A GASKET FAILS, THE LEAK IS DETECTED ON THE OUTSIDE OF THE PLATE PACK

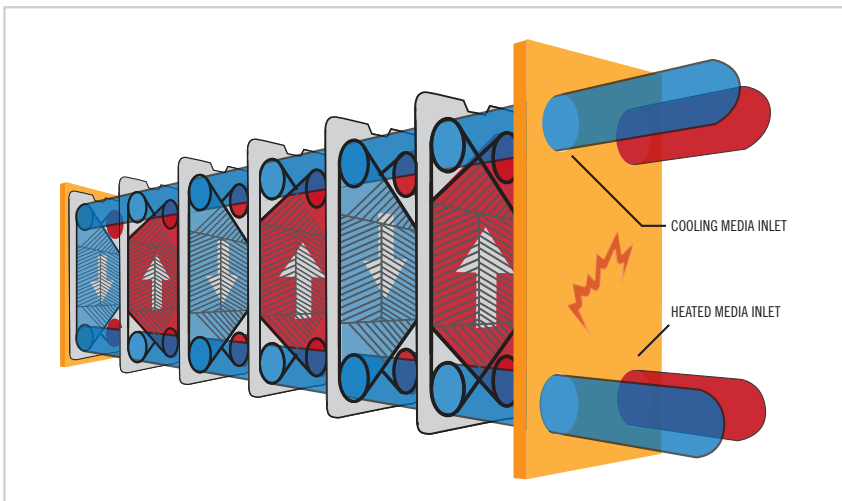


T.H. Industrial Solutions goal is to supply the most common and obscure, or hard to find gaskets. We offer custom fabrication and laser cutting for unique metal style gasket requirements.

We supply direct replacement gaskets for Alfa Laval, Vicarb, Graham, Mueller, ITT, Armstrong, Fischer, Tranter, Bell & Gossett, APV, & Sondex.

Advantages of a PHE are:

- **Servicing** – plates are removed easily for maintenance cleaning or replacement
- **Small Footprint** – the design is compact, requiring less space than a shell & tube heat exchanger
- **Efficiency** – higher heat transfer from a greater fluid distribution over a larger surface area which rapidly increases the speed of the temperature changing
- **Expandable Design** – plates can be easily added to increase the required heat transfer capability



Disadvantages of a PHE are:

- **Contamination** – over time plates will become build up with scale and debris
- **Replacement** – gaskets tend to leak after 10-13 years and will require replacement
- **Application** – not compatible for higher temperature and pressure

WHAT CAUSES PLATE & FRAME HEAT EXCHANGERS TO LEAK EXTERNALLY?

1. Rubber gaskets installed on each plate create a seal, when gaskets become worn or damaged;
 2. As the PHE ages the gaskets can dry out, lose their elasticity and become brittle;
 3. Operating temperatures, pressures and exposure to process fluids can all reduce the life of a gasket;
 4. Spiking or water hammer can force a gasket out of the plate groove;
 5. Overheating can melt the rubber and cause the gasket to become brittle and crack;
 6. Over tightening the groove the gasket sits in can become deformed. When this occurs the gasket will not sit flat & pushes outwards.
- *.4mm thick gaskets are very susceptible to this issue*



WHAT CAUSES PLATE & FRAME HEAT EXCHANGERS TO LEAK INTERNALLY?

1. Higher pressure side will leak into the lower pressure side, if a plate develops a pin hole or crack;
2. Over time the plates can crack since they are continuously flexing, this is often referred to as a “pop can effect” - continually bending the can back and forth in the same area will break it apart;
3. Cross contamination is preventable when “double walled” designed plates are used with potable water.
**Municipal codes verify from region to region with most new construction by-laws requiring this safety measure*



ADDITIONAL GENERAL PHE INFORMATION

- The life span of a gasket in a cooling application is 10-15 years and for a heating application 8-10 years;
- Gaskets exposed to steam will typically wear quicker than if exposed to boiler water;
- PHE's used strictly for seasonal heating will often leak during the first month of startup and seal after a few weeks as the gaskets expand.

WHEN SHOULD A PLATE & FRAME HEAT EXCHANGER BE SERVICED?

As a heat exchanger becomes fouled with dirt, debris or scale, often the modulating valve provides additional hot or cold liquid to help compensate for the loss of efficiency of the heat exchanger.

Over time the control valve will continue to open fully. Unfortunately, on the hottest or coldest days, even with the valve fully open the heat exchanger cannot meet the thermal transfer requirements and the situation becomes critical.

Monitoring just the operating temperature provides a false sense of security. Recording the difference in the outlet and inlet pressures provides a more accurate result of the amount of fouling.

Fouling equal to the thickness of a piece of paper represents a 20% loss of thermal efficiency. In addition, the energy cost for pumps increases since the pump must work harder to overcome the increased pressure resistance through the PHE.

Differential pressure average for a PHE equals 2-4 psi when equipped with new or refurbished plates.

PHE service should be scheduled when the differential pressure increases up to 7-10 psi.

Fouled Plates

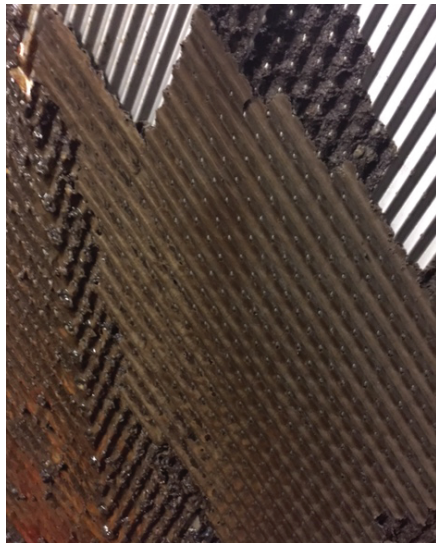
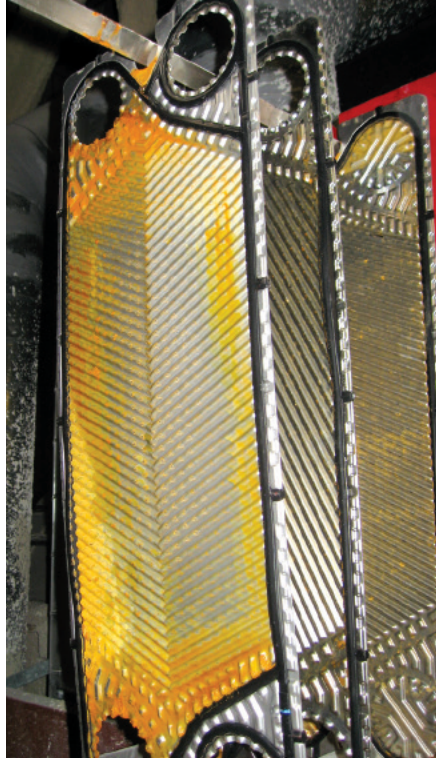
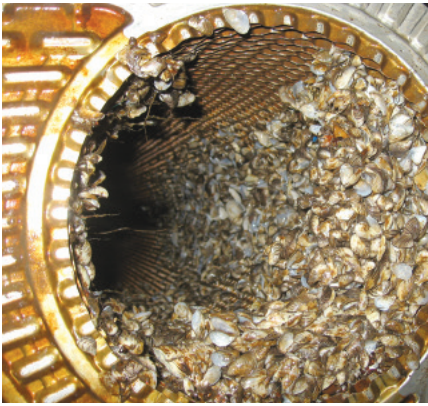


PLATE & FRAME HEAT EXCHANGE CLEANING SERVICE OPTIONS

CHEMICAL FLUSHING (1-2 DAYS) ON-SITE

A portable chemical flushing unit consists of a pump, tank, filter and hoses. THS service technicians pump a citrus based cleaning chemical or mild acid solution through the heat exchanger for 6-8 hours, during the flushing any debris is collected in the filter.

**The volume and velocity of the pump package is limited, PHE's over 3 ft in height and with connections over 2", will not experience significant benefits using this sized pump package since most power supplies available are 120V*



HIGH PRESSURE PUMPS (1-2 DAYS) ON-SITE

PHE's can be taken apart and cleaned with high pressure water. The water is effective in cleaning dirt and biofilm, however may not remove scale and rust buildup. Clip or ball style gaskets can be supplied and changed on-site during service; glued gaskets should be removed off-site.



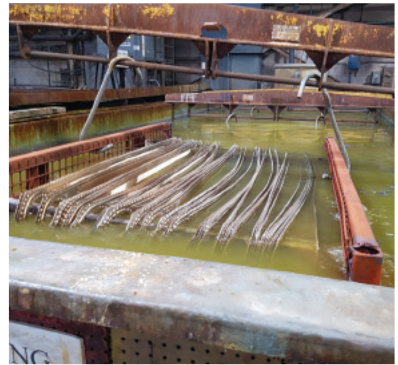
**Chances of a PHE leaking increases to 50-60% probability when re-assembling a unit using gaskets that are over 10 years old, visibly damaged or brittle, causing the PHE not to seal completely. In addition, each time a PHE is taken apart the gaskets can be potentially damaged or may not reseal correctly when retightened.*

FULL SERVICE (2-3 WEEKS) OFF-SITE

- The most effective method to remove glue style gaskets is to complete the service off-site.
- Plates are submerged in either a caustic acid bath or nitrogen to break the glue bond.
- After the gaskets have been removed, the plates are submerged in a second bath of heated phosphoric or hydrofluoric acid to remove scale and contamination.
- Using this method plates are returned 95% - 99% to new condition.
- The plates are then cleaned with water and a Infiltration UV Tracer is applied.

(if there are pinholes or cracks in the plates the dye test reveals this.)

- Rubber adhesive is then applied to the plate groove and new gaskets are installed.



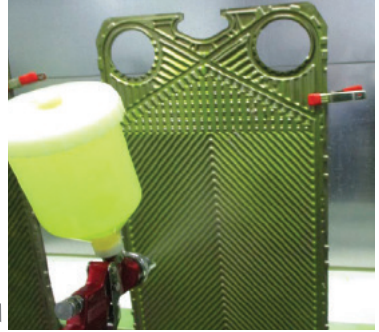
LEAK AND DAMAGE DETECTION SERVICE OPTIONS

PRESSURE TESTING

The primary side is filled under pressure with air or water, the secondary side is pressure free. On a plate defect, there's a pressure reduction on primary side.

CONUCTOMETRY TESTING

The primary side is filled e.g. with sodium sulfate, the secondary side with water. Driven by the osmotic differential pressure the tracer substance diffuses on the water side.



INFILTRATION UV TRACER

The surface of the plates must be chemically cleaned, then a fluorescent color is up-sprayed on each plate.

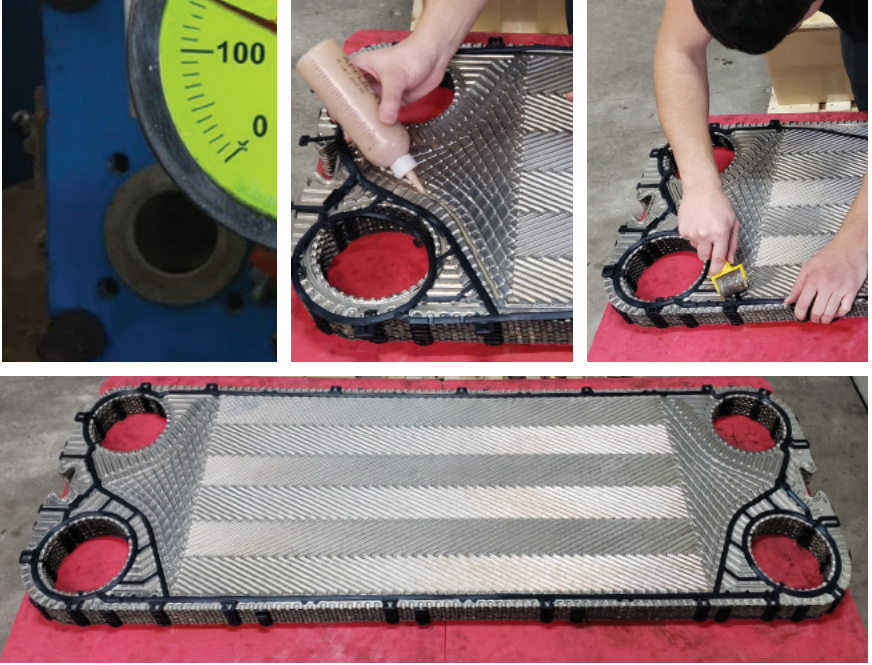
After a response time each plate is checked with UV light in a darkened area.



**Dye penetrant is applied to damaged plates for customers revealing the pinholes or cracks in the affected area.*



GASKET INSTALLATION



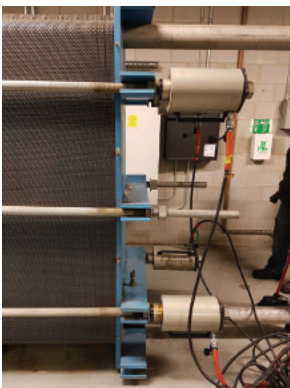
** Gasket and/or Plate Delivery (depending on shipping location):*

- *stock approximately 1-3 weeks*
- *non-stock approximately 6-12 weeks
(must be molded and/or stamped)*

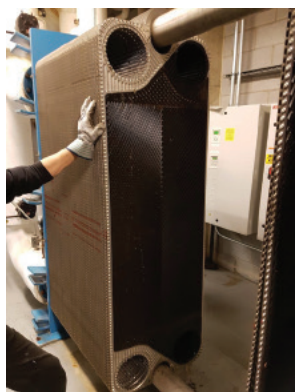
** Complete replacement is often not practical:*

- *due to the weight and size of many heat exchangers*
- *accessibility to mechanical rooms is often severely limited*
- *many heat exchangers were installed during initial construction before walls were installed*
- *major piping changes are often required when installing new heat exchangers*
- *piping standard connections may have changed from a diagonal pattern (X) to parallel*

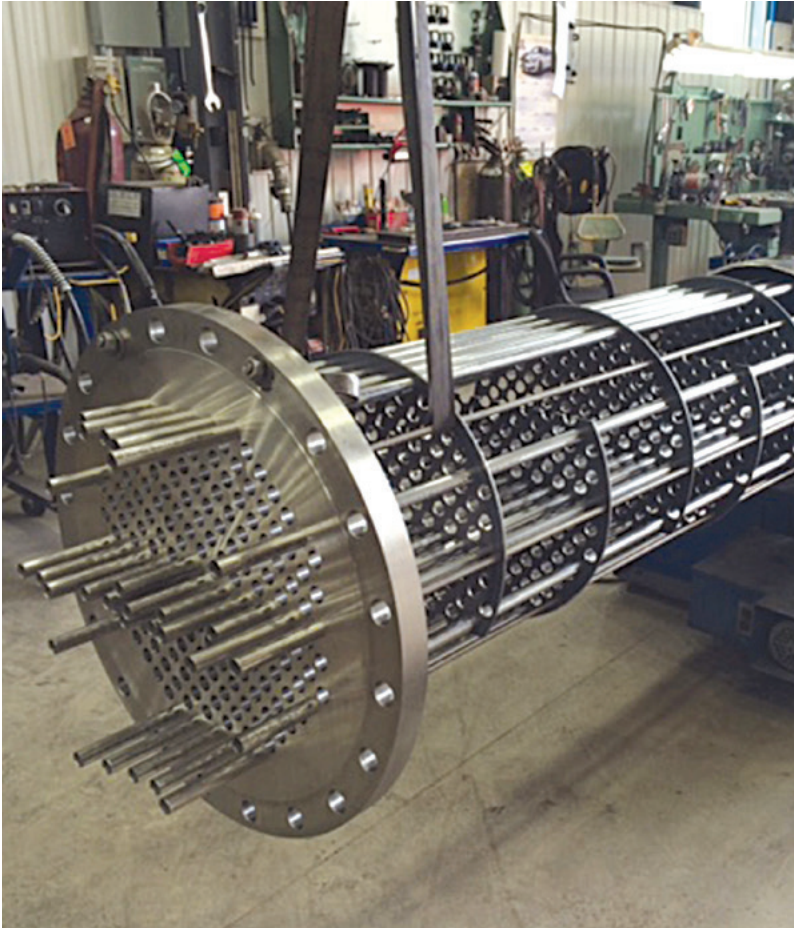
USING HYDRAULICS PLATE & FRAME



TO DISASSEMBLE A HEAT EXCHANGER

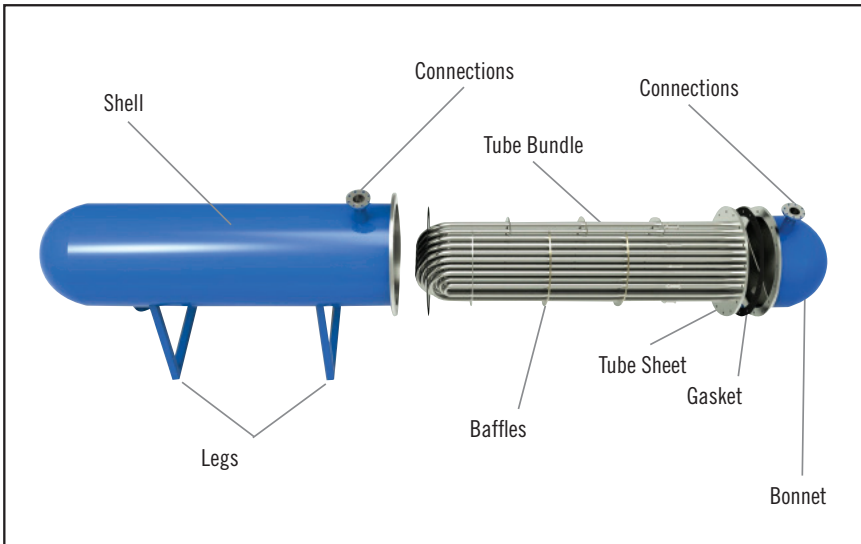


SHELL & TUBE HEAT EXCHANGERS



SHELL & TUBE HEAT EXCHANGERS

The main components of a Shell & Tube Heat Exchanger consist of the following:



ADVANTAGES OF A SHELL & TUBE HEAT EXCHANGER ARE:

- **Tubes** – less likely to plug and foul
- **Gaskets** – typically only 2-4 gaskets to replace
- **Application** – higher pressure and temperature used
- **Design** – basic, heavy duty, rugged and durable
- **Lifespan** – average life of a shell and tube is 15-20 years, however, it is not uncommon to have shell and tube heat exchangers in service for over 30 years

DISADVANTAGES OF A SHELL & TUBE HEAT EXCHANGER ARE:

- **Efficiency** – not as thermally efficient as a PHE
- **Footprint** – larger size in comparison to a PHE

TUBE BUNDLE COMPONENTS

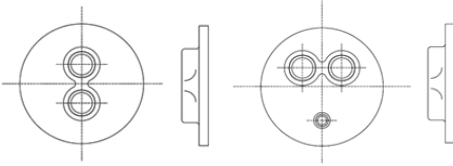
The tubes are typically copper or stainless steel with a $\frac{3}{4}$ " or $\frac{5}{8}$ " outside diameter, while the remaining components are usually manufactured from milled steel.

Tie rods (circular metal rods) and spacers hold the tube bundle together while holding the baffles in the correct position. The tie rods are fastened into the tube sheet then secured at the farthest baffle. The number of tie rods, baffles and tubes depends on shell diameter and required application.



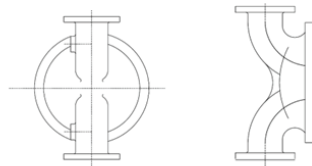
SHELL & TUBE BONNET TYPES

Bonnet Type #1



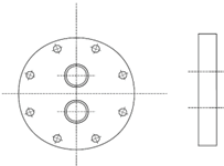
2 Pass

Bonnet Type #2



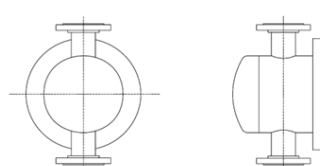
2 Pass

Bonnet Type #3

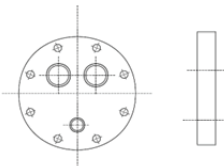


2 Pass

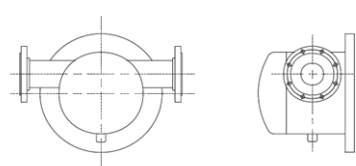
Bonnet Type #4



2 Pass

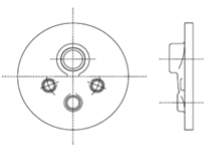


4 Pass

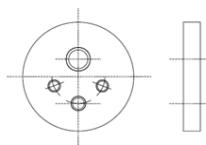


4 Pass

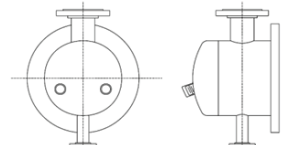
Steam Bonnet Types



2 Pass

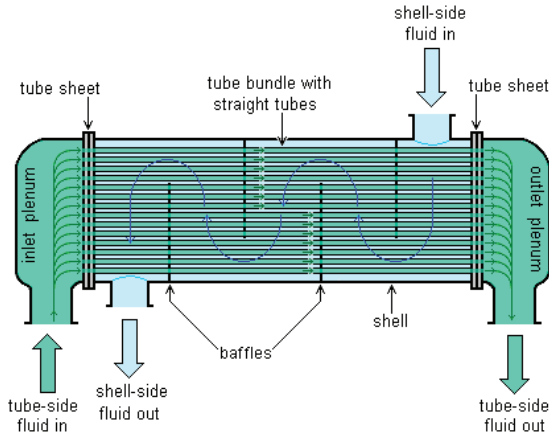


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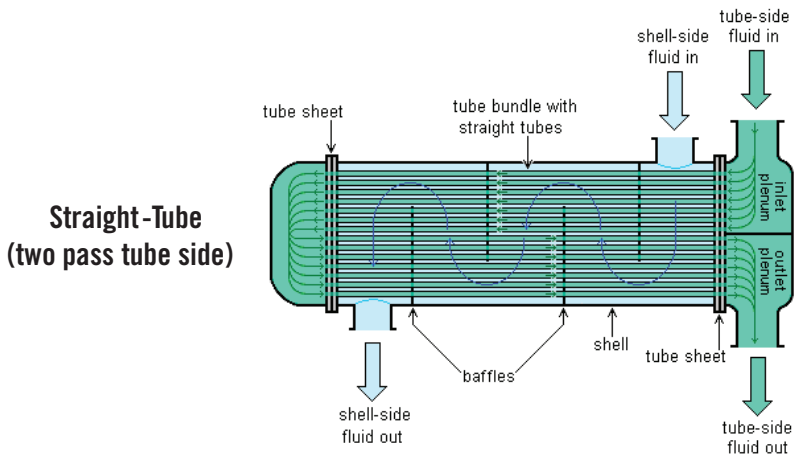


4 Pass

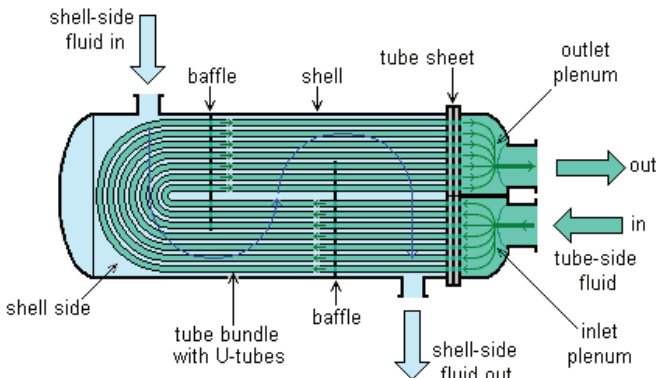
COMMON SHELL & TUBE HEAT EXCHANGER DESIGNS



**Straight-Tube
(one pass tube side)**



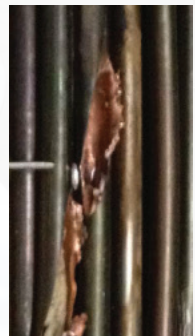
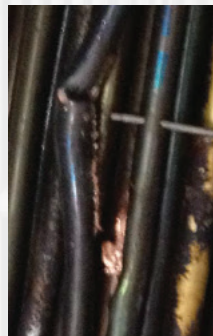
**Straight-Tube
(two pass tube side)**



U-Tube

SHELL & TUBE HEAT EXCHANGERS ISSUES

1. When vacuum breakers or thermostatic vents are not installed or functional the tube can be sucked in and break.
2. If the bundle is subjected to temperature extremes, (thermal shock), the tubes will develop spiral cracks.
3. On steam applications, harmonics can occur. This constant vibration can cause the steel baffles to eventually cut into the copper tubes.
4. Chemical corrosion resulting from interaction between the heat exchanger and the circulated fluids.
5. Marine film or coating on tubes such as scale, mud, algae and zebra mussels plugging tubes, this results in higher corrosion and restricts heat flow.



SHELL & TUBE HEAT EXCHANGER CLEANING OPTIONS

CHEMICAL FLUSHING (1-2 DAYS) ON-SITE

A portable chemical flushing unit consists of a pump, tank, filter and hoses. THS service technicians pump a citrus based cleaning chemical or mild acid solution through the heat exchanger for 6-8 hours, during the flushing any debris is collected in the filter.



**The level of success for this cleaning method is determined by the amount and type of contamination. If the scale has hardened, which is very common on heating applications, the chemical flush effectiveness can be limited.*

CLEANING RODDING OR DRILLING TUBES (2-3 DAYS) ON-SITE

Recommended for heat exchanger tubes that have hardened scale, the bonnet must be removed. Tube cleaning brushes, or drills, are inserted into each tube and the scale and contamination is grinded or cut away.



PRESSURE TESTING, TUBE VACUUM TESTING, TUBE REPLACEMENT AND PLUGGING ON OR OFF SITE

THS is also equipped to provide pressure testing, individual tube vacuum testing, complete tube replacement and tube plugging both onsite and at our service facilities.

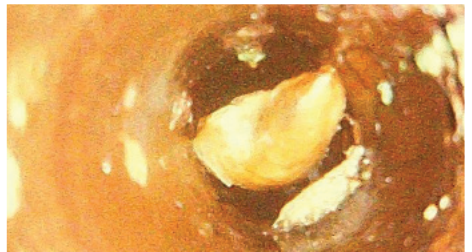
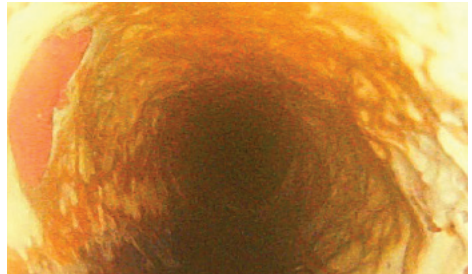
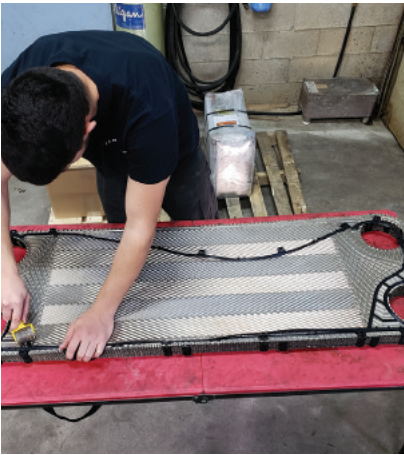


CHEMICAL CLEANING OFF-SITE (2-3 WEEKS)

Tube bundle or complete heat exchanger is serviced at one of our service facilities. A mild acid solution is pumped through the heat exchanger for 6-8 hours, during the flushing all debris is collected in the filter. Before and after flow rates are recorded to gauge the effectiveness of the cleaning. A borescope is utilized to examine the tube internals. Pressure testing is completed on both the bundle and shell.

**Extreme fouling applications - tube bundle is submerged in a heated chemical bath. After 4 hours the bundle is removed and high pressure washed. If the contamination remains the process is repeated.*

Borescope images of tube internals *Blockage in Bottom Tube



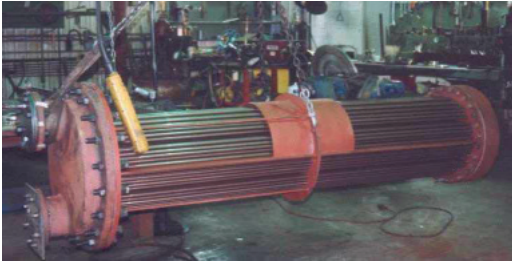
**Complete Replacement of Shell and Tube Heat Exchanger Delivery (depending on location):*

- *Stock approximately 2-4 weeks*
- *Custom fabricated tube bundles can be manufactured in 6-10 weeks*

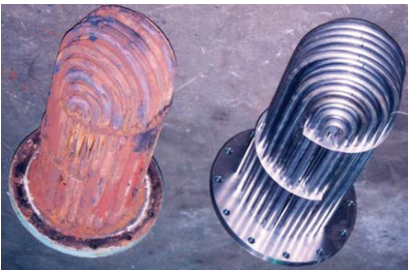
**Without drawings, the bundle will need to be removed and measured to fabricate a replacement*

**Due to the large footprint, accessibility is often a major issue*

SHELL & TUBE SERVICE BEFORE AND AFTER IMAGES



SHELL & TUBE SERVICE BEFORE AND AFTER IMAGES



HEAT EXCHANGER RISK ASSESSMENT GUIDE

WHAT ARE THE EFFECTS FROM A FAILED HEAT EXCHANGER?

- loss of production
- loss of revenue
- no common area heating or cooling in condominiums or hotels
- no cooling for the computer main frames in office towers
- no hot water for hospitals, hotels and condominiums
- no hot water for pools and hot tubs

Without a backup contingency plan what is the effect on business or property interruption?

At a minimum, service interruption due to a broken heat exchanger is 1 day, without a spare bundle, plate pack or gaskets the interruption could be 1-6 weeks depending on the severity of the repair and/or availability of parts.

NOTES:

HEAT EXCHANGER DATA

Make:	Model Number:
Manufacture Date:	Serial Number:
Application <i>(heating/cooling)</i>	Service <i>(water/glycol/steam/other)</i>

PLATE AND FRAME HEAT EXCHANGER	SHELL & TUBE HEAT EXCHANGER
Operating Pressures Side 1: Side 2:	Operating Pressures Shell: Tube:
Operating Temperatures Side 1: Side 2:	Operating Temperatures Shell: Tube:
Number of Plates Flow # Starter# Port #	Number of Tubes # Number of Baffles #
Gasket Material <i>(NBR/EPDM/Viton)</i>	Shell Material: Tube Material:
Gasket Style <i>(glue/clip/ball)</i>	Gasket Material <i>(NBR/EPDM/Viton)</i>

Pressure Inlet:	Pressure Outlet:
Differential Pressure:	Last Service Date:



OUR GOAL IS TO SOLVE YOUR PROCESS PROBLEMS

On-Site and Off-Site Services available:

Heat Exchanger Service in Canada, Replacement Gaskets & Plates, Pressure Testing Shell & Tube / Plate & Frame Heat Exchangers, Chemical Cleaning & Descaling of Pipes, Tanks, Boilers, Air Coolers etc, Oxygen & Silicone Cleaning, Pipe/Tank Passivation, Valve Selection/Automation, Borescope Inspection

Filtration Systems Sales/Service including:

Sand Filters, Centrifugal Separators, Disc Filters, Magnetic Filters, Indexing Filters, Self-Cleaning Screen Filters, Wedge Wire Filters & Strainers

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January 1, 2018

To whom it may concern,

This letter is to confirm that TH- IS (Total Heat Exchangers - Industrial Solutions) are a factory approved service dealer of Armstrong Fluid Technology (S.A. Armstrong Ltd.) and have been since December of 2009.

They are qualified and authorized to conduct field service, including field assembly, commissioning and repair services which require special knowledge, skills and equipment, on behalf of Armstrong Fluid Technology (S.A. Armstrong Ltd.).

Yours truly,
S.A. Armstrong Ltd. / Armstrong Pumps Inc.

Joseph Tibando
Manager of Global Service

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ARMSTRONG FLUID TECHNOLOGY
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Double Walled Heat Exchanger Requirements

Designers and installers are required to conform to the following requirements.

7.6.2.1. Connection of Systems

(1) Connections to potable water systems shall be designed and installed so that non-potable water or substances that may render the water non-potable cannot enter the system.

(2) No connection shall be made between a potable water system supplied with water from a drinking-water system and any other potable water system without the consent of the water purveyor.

Therefore, if the designers, manufacturers and installers cannot assure that, "non-potable water or substances that will NOT render the water non-potable" (i.e. warranty of a single wall heat exchanger does not work, it only means when there is a break, someone will fix it but the damage has been done), as such, fail safe design must be included within the design and installation.

The local authority having jurisdiction can accept either an applicable Acceptable Solution in Division B, or an applicable Alternative Solution that will achieve the level of performance required by the applicable Acceptable Solution in respect of the Objectives and Functional Statements attributed to the applicable Acceptable Solutions in Supplementary Standard SA-1.

Under the Building Code Act, the local municipality is the authority having jurisdiction for enforcing the Act and its Regulations, and the permit applicants should contact the appropriate official with respect to any specific proposal. Danny Hui, P.Eng. Building Code Advisor Building Services Specialist Code Advisory Unit Building and Development Branch Ministry of Municipal Affairs & Housing Tel: 416-585-7368

REFERENCES

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3RD PARTY ACCREDITATION





T. H. Industrial Solutions

Total Heat Exchanger Solutions

a division of T. H. Industrial Solutions

- Plate & Frame
- Shell & Tube
- Sales / Service
- Cleaning / Testing / Regasketing



PUROFLUX CORPORATION

- Sand Filters
- Centrifugal Separators
- Tower Sweeping Pkgs



FILTER SOLUTIONS INC

protecting clean operations

- Custom Bag Filter Vessels
- CRN / ASME
- Cartridge Filters



- Tube Bundle Complete Construction / Re-Tubing





- Butterfly Valves
- High Performance Butterfly Valves
- Check Valves
- Ball Valves



- Self Cleaning Indexing Media Filters
- Custom Bag Filters



- Magnetic Filtration
- Custom Rare Earth Magnets



- Bi-Metal Thermometers
- Pressure Gauges
- RTD's



- Heavy Duty Radiator Service
- Fin Coil
- Shell & Tube



As part of our corporate social responsibility, each time an order is placed with our company a tree will be planted by Forests Ontario. Over a lifetime, with the addition of each tree, eventually a forest will be created which will help to ensure the health of our environment for future generations to come.



NOTES:



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