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Understanding the Basics

Temperature Approach or CTD:

Hot fluid inlet 120ºF → 95ºF Hot fluid outlet

Cold fluid outlet 110ºF ← 85ºF Cold fluid inlet

Difference between the hot outlet and cold inlet temperatures is called CTD (cold temperature difference) or temperature approach. The closer the temperature approach, the more heat transfer area needed for the duty.

Plate exchangers can handle 2ºF temperature approaches!

What is the temperature approach for this duty?

Understanding the Basics

What determines a heat exchanger design:

- Flow rate
- Operating temperatures (hot & cold side inlet and outlet)
- Operating pressures of each fluid
- Pressure loss allowed across the exchanger
- Fluid characteristics (density, specific heat, thermal conductivity and viscosity)
- Cleanliness of the fluids being handled

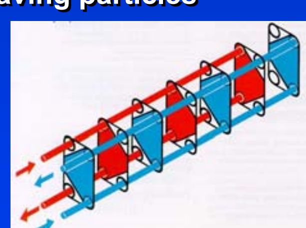
Plate & Frame Exchangers

Advantages

- **Most efficient heat transfer device for liquid to liquid duties**
- **Expandable – can easily add or remove plates**
- **Easy to access for inspection or cleaning**
- **Relatively inexpensive compared to tubular and spiral units**

Disadvantages

- **Does not handle liquids over 400ºF and 450 PSIG**
- **Does not accommodate gases very well, except low pressure saturated steam 50 PSIG or less.**
- **Limitations with fluids having particles**



Choosing a Plate Exchanger

Type of Service:

- Liquid to Liquid →
- Liquid to Steam →
- Liquid to Gas -- Maybe, low odds
- Gas to Gas ----- No good

Operating Temperatures:

- Equal to or Below 400ºF →

Operating Pressures:

- Equal to or Below 450 PSIG →

Choosing a Plate Exchanger

Solids & Particles:

<u>Round</u>:

- <= 1/16” dia. = standard PHE →
- <= 1/8” dia. = wide gap PHE →
- > 1/8” dia. ------- No good

<u>Long Stringy</u>: ------- No good

Materials of Construction:

- CS – flowrates >150 GPM →
- Stainless Steel – big savings →
- All other Alloys – big savings →

Compact Size Required: →

Today's Agenda

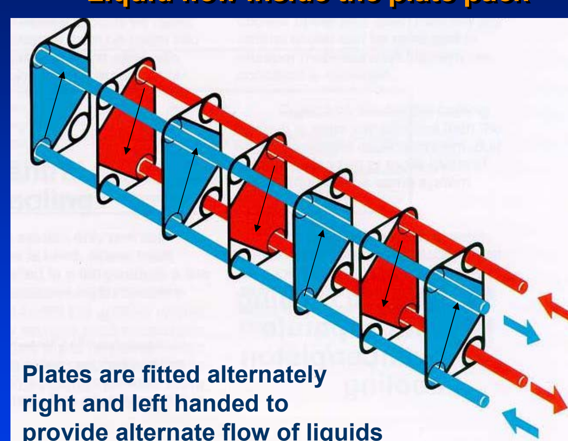
Plate Heat Exchanger Design:

- How do they work
- Heat Transfer Plates
- Gaskets
- Frames
- Configurations

How Plate Exchangers Work

Plate Exchanger

Liquid flow inside the plate pack



Hot Fluid

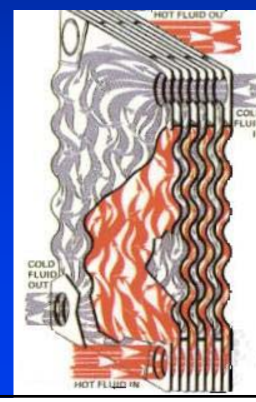
Cold Fluid

Heat Transfer Plates

Heat transfer plates have corrugations or troughs that give the plate strength, with operating pressures to 450 PSIG.

Turbulence is induced in the liquid channels.

Cutaway of the heat transfer plates show turbulence during passage of the product and service liquids.



How Plate Exchangers Work

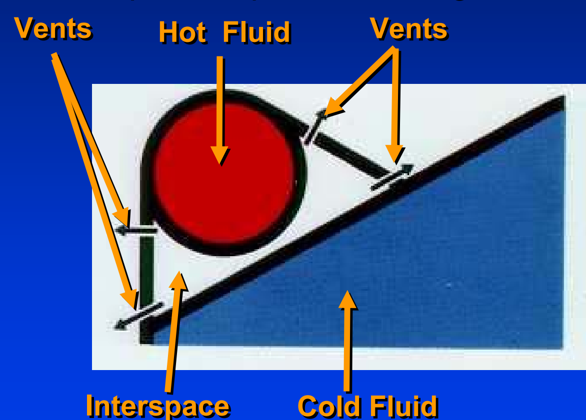
Cold fluid is permitted to flow on this side of the plate.

Each gasket is a single membrane around the perimeter of the plate to seal the liquid in a narrow channel.

Gasket ring prevents hot fluid from flowing down this side of the plate.

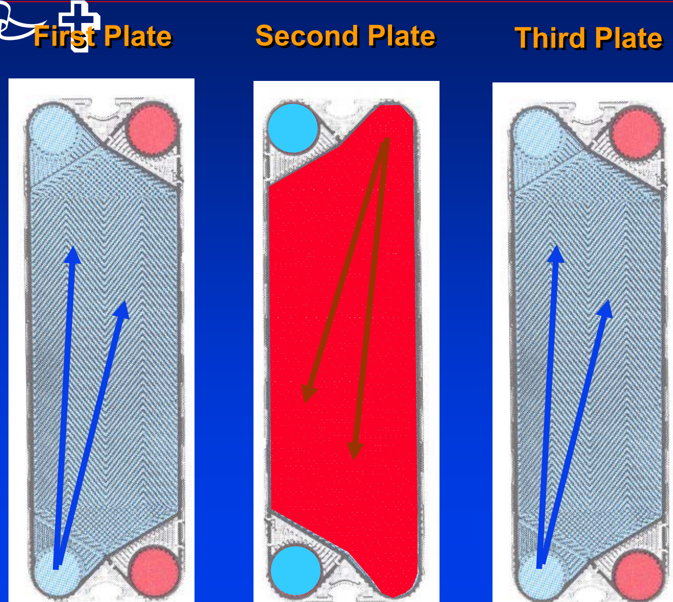
How Plate Exchangers Work

The port area has a double gasketed seal to prevent product mixing.



The interspace is vented to atmosphere for leak detection.

How Plate Exchangers Work



Always look at the gasketed side of the heat transfer plate

Heat Transfer Choices

Plate Heat Exchanger choices available:

Single gasketed plate

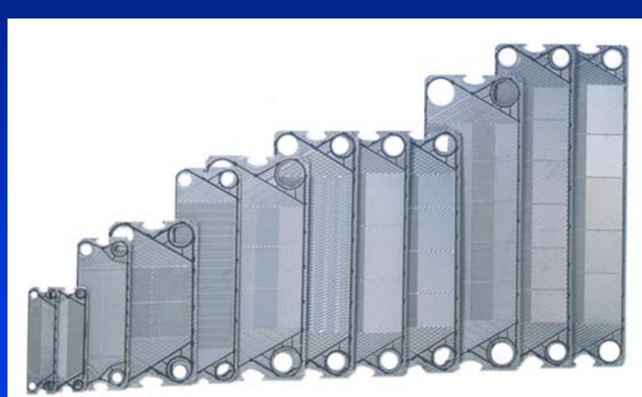
Duo-Safety (double wall)

Welded plate pairs

Brazed

Gasketed Single Wall Plates

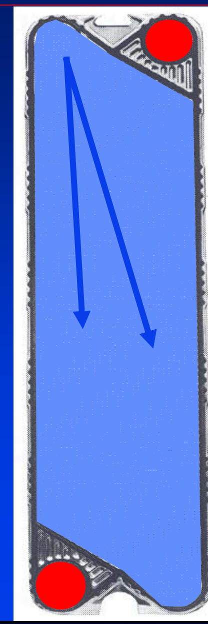
Single wall gasketed heat transfer plate can be pressed in either a **washboard** or **chevron** design.



Washboard Plates

Features:

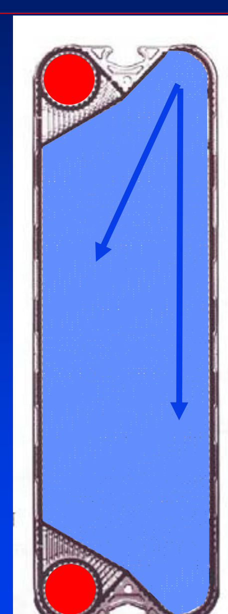
- ✓ Diagonal flow orientation
- ✓ Used for high viscosity or high solids liquids



Chevron Plates

Features:

- ✓ Same side flow orientation
- ✓ Extremely efficiency design
- ✓ Plate thickness from 0.4 to 0.8 mm
- ✓ Different plate angles that can be mixed to optimize performance
- ✓ Narrow and wide gap designs
  - Narrow - particles 1/16”or smaller
  - Wide - particles 1/8”or smaller



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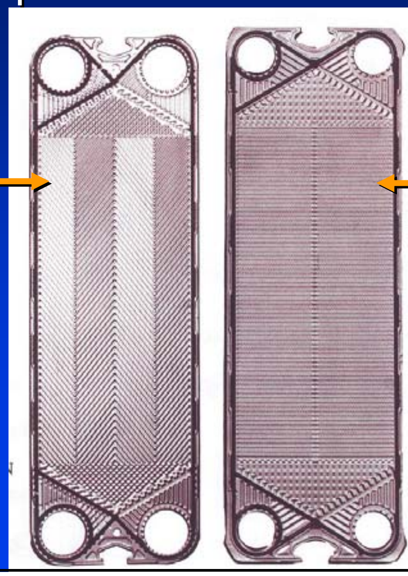
Chevron Plates

Chevron plates can have different angles.

Soft Plate
(50° angle)
Thermally
short



Hard Plate
(0° angle)
Thermally
long

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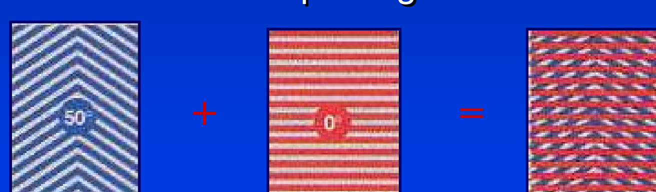
Chevron Plates

Mixing different plate angles can improve heat transfer.

Low heat transfer passage



High heat transfer passage

Chevron Plates

Plate angles vary by model and manufacturer.

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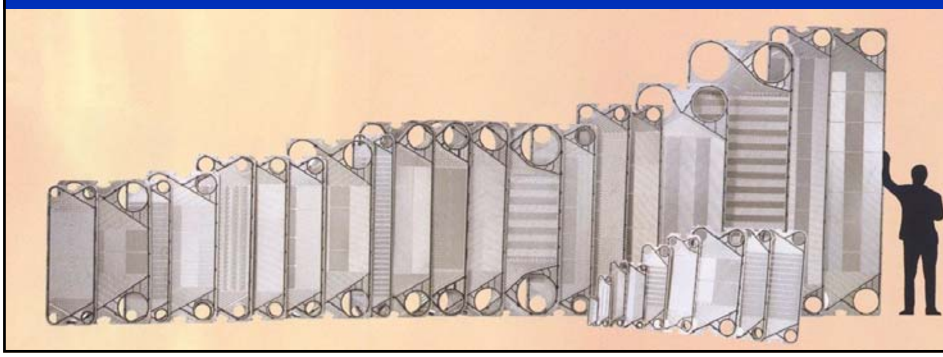


Easy Clip Gaskets

The EasyClip system is a patented, glue-less system, which secures the gasket to various points on the heat transfer plate.

During fixing the gasket a pressure is applied, which expands 2 tongues into 2 slots in the plate. This barbed effect (fish hook) secures the gasket to the plate. In fact it now takes more force to remove the gasket than to apply it.

Easy Clip Gaskets

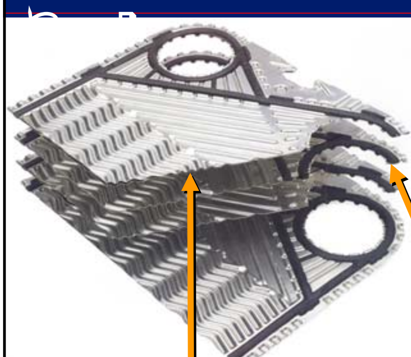
Easy and rapid gasket change out

To affix the gasket, pressure is applied which expands 2 tongues into 2 slots in the plate. Gaskets “receive” the neighboring plate.

This barbed effect (fish hook) secures the gasket to the plate. In fact it now takes more force to remove the gasket than to apply it.

No glue or heat treating is needed!

Gasketed Double Wall Plates



APV’s patented Duo-safety plate consists of two loose plates equipped with a non-glue press in gasket, which seals and holds the pair together.

Detail of the two loose plates that make up a duo-safety plate

Sealing detail of the duo safety plate

Gasketed Double Wall Plates

Duo-Safety plates provide you:

- Protection against cross-contamination
- Alternative to pressure control systems
- A simple, robust and approved system
- The latest technology available

Advantages over a pressure control system:

- No booster pump
- No back pressure valve
- No additional pressure sensors
- Reduced power consumption
- Reduced maintenance
- No cavitation problems

Gasketed Double Wall Plates

Advantages:

✓ Air gap between plates provides certainty liquids will not mix

✓ A weld free plate enabling complete visual inspection of the plates

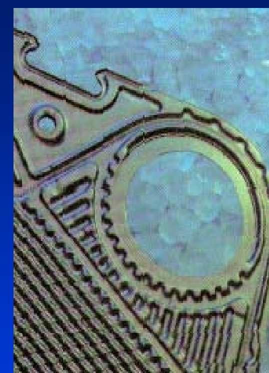
✓ Can mix different plate materials in one plate pair to keep capital equipment costs to a minimum

Common Application:

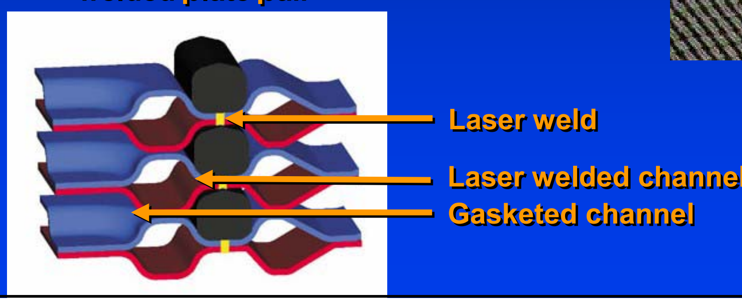
- Any process that requires absolute certainty the fluids will not cross contaminate

Welded Plate Pairs

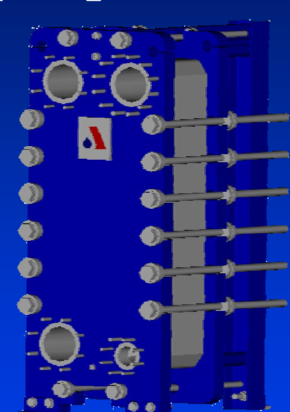
APV Para-weld consists of two plates laser welded to form a leak-proof, gasket-less channel on <u>one</u> of the fluid sides. The other fluid channel has a gasket on it.

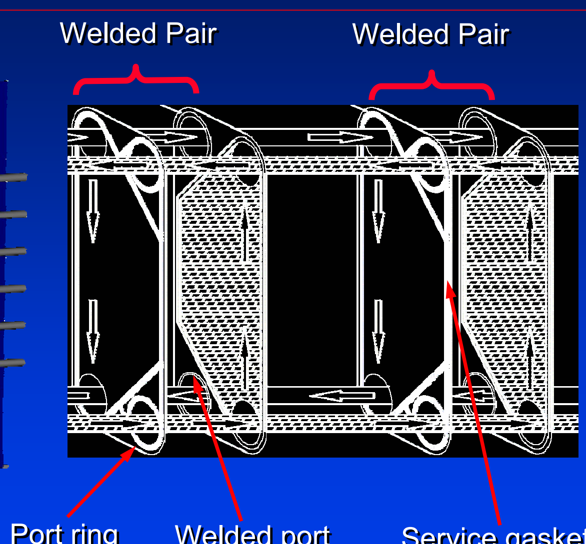


Sealing detail of the laser welded plate pair



Welded Plate Pairs





Welded Plate Pairs

Advantages:

- ✓ Flexibility – more plate pairs can be added later
- ✓ Security – Twin welding paths ensure against leakage
- ✓ Easy to maintain – welded channels can be chemically cleaned. Full access on the gasketed channel side.
- ✓ Compact – very small footprint and profile compared to shell and tubes or all welded exchangers.

Common Applications:

- Acid and/or caustic solutions
- Chiller with ammonia/freon

Welded Plate Pairs

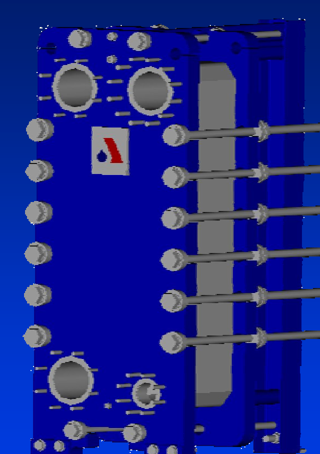
Models having the welded pairs:

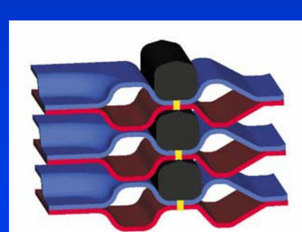
2” LR 2 Plate

4” LR4 Plate

8” LR9 Series Plates in four sizes

12” BL Series Plates in five sizes





Brazed Plate Exchangers

A ParaBrazed Heat Exchanger is soldered and therefore can not be opened. There is no need for a top carrying bar, bottom guide bar, or tie bars. Plates are between a thin frame.

Plate Materials Available

Stainless Steels:

- **304 stainless steel**
- **316 stainless steel**
- **904L stainless steel**
- **Avesta 254 SMO**

Nickel Alloys:

- **Nickel 200**
- **Hastelloy B, C, & G**
- **Inconel 625**
- **Incoloy 825**
- **Monel 400**

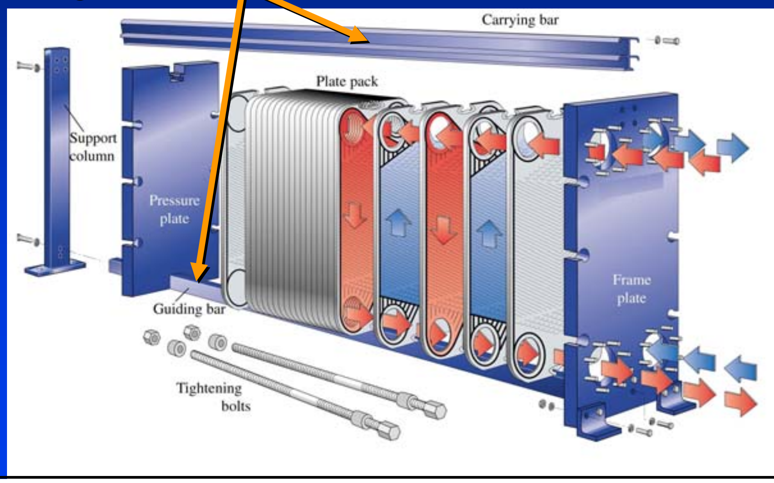
Other metals:

- **Titanium**
- **Titanium-Palladium**

Carbon steel can not be pressed into a heat transfer plate

Sealing Plate Exchangers

To ensure a good fit in the frame the heat transfer plates hang from a top carrying bar and guided by a lower guide bar.

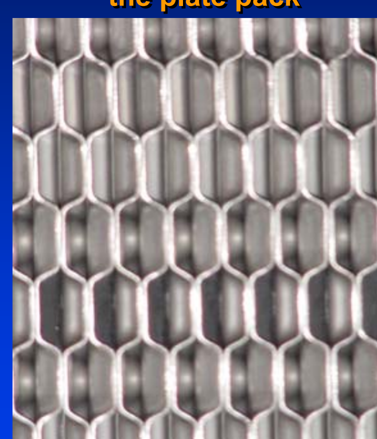


Sealing Plate Exchangers

To ensure a leak free design, always use a plate heat exchanger that has the gasket completely encapsulated by the heat transfer plates.

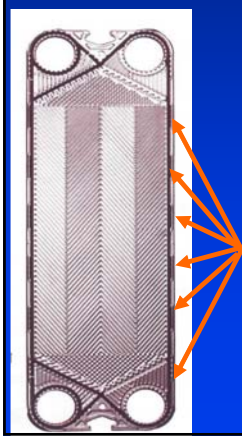
When tightened, the plate pack will produce a honeycomb design. The gasket is never exposed to atmosphere, minimizing the potential for pressure blow out.

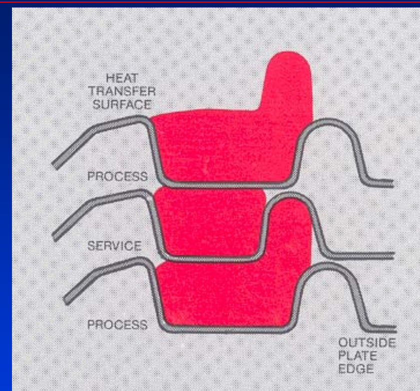
Outside view of the plate pack



Sealing Plate Exchangers

To provide even greater assurance no gasket will leak or blowout, one supplier offers the interlocking gasket.



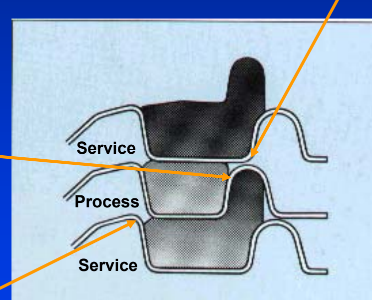


Raised lugs found intermittently on the gasket mate with a pressed groove provide mechanical plate-to-plate support for the sealing system.

Paraflow Gaskets

The unique raised lug design:

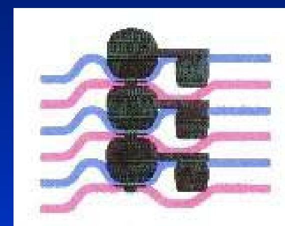
1. Provides 100% peripheral support of the gasket, leaving none of the material exposed to the outside.
2. Maintains plate alignment during plate closure and operation.
3. gasket and groove design minimize gasket exposure to the process liquid.

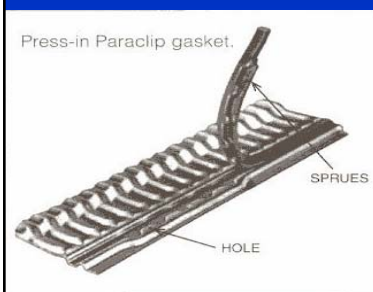


Paraflow Gaskets

Gaskets are available in **glue in** or **press in** style.

Press in gaskets do not require glue or heat treating. Regularly spaced spruces on the gasket mate with slots on the heat transfer plate anchoring it securely in place.





Press in advantages:

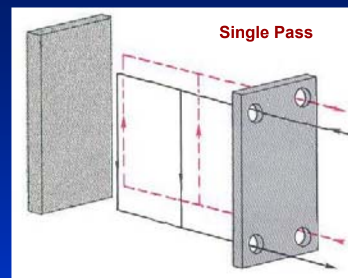
- Simply press into place
- No cementing or heat treating
- No special tools required
- Easily done onsite

Paraflow Gasket Materials

Material	Max. Temp.	Applications
Neoprene	185ºF	Used for ammonia and freon refrigeration.
Nitrile (NBR)	275ºF	General purpose for aqueous and fatty duties, including edible and non-edible oils.
EPDM	300ºF	High temperature resistance for various chemicals, including steam. Can not be used for oils.
FPM (vitons)	400ºF	For a wide range of organic solvents, chemicals and oils. Resistant to steam, hot water, and various acids.

Single Pass Design

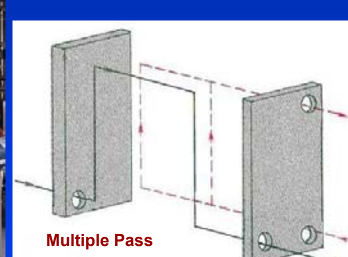
1. The preferred configuration
2. All connections are located on the fixed cover (head)



3. Do not have to disturb piping to inspect or access plates.
4. Keeps pressure drop across the unit to a minimum

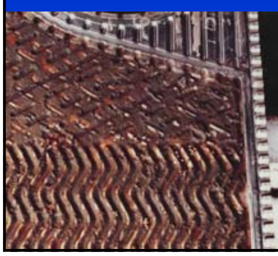
Multiple Pass Design

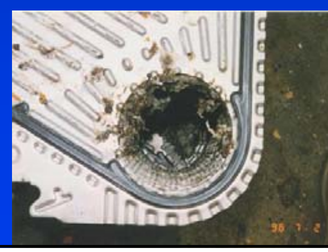
1. Increases the heat transfer area
2. Keeps a sufficient plate velocity
3. Minimizes the number plates required in the unit
4. Multi-pass is typically used for many food products



Problems with Fouling

How To Accommodate For
Fouling And
Specify Fouling Factors
In
Plate Heat Exchangers



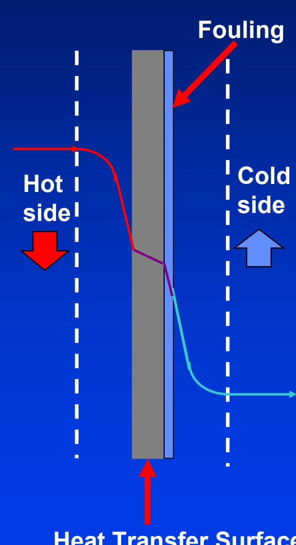


Problems with Fouling

A reduction in heat transfer can occur due to fouling (scale build up or deposit) and must be considered when specifying or designing a heat exchanger.

The fouling rate is determined by the composition of the fluids, operating temperatures, the detail designs of the heat exchanger, velocities, turbulence and the type of fouling.

Filtering the fluids upstream of the heat exchanger and prior heat treatment have a big impact on fouling growth rate.



Four Most Common Types of Fouling

- Crystallization: Most common type, formation of crystals.
- Sedimentation: Deposit of particulate matter (clay, sand).
- Bio-fouling: Organic growth matter.
- Chemical Reaction or Polymerization: A build up of organic compounds or polymers.

With certain fluids, there can be a combination of these types of fouling occurring. For example, cooling tower water can have crystallization, sedimentation, and organic material growth.

Problems with Fouling

Fouling leads to:

- A reduction in heat transfer leading to a loss of plant capacity and/or efficiency
- Higher pressure loss across the heat exchanger
- Higher risk of corrosion
- Increased maintenance costs
- Added cost of cleaning & treatment chemicals
- Hazardous cleaning solution disposal
- Reduced service life and added energy costs
- Increased costs of environmental regulations

Dealing with Fouling

Most heat exchanger manufacturers will add additional heat transfer surface (spare capacity) to accommodate for fouling. However, since the fluid conditions can vary, no manufacturer warranties against fouling.

Fouling is described in different ways depending on the industry.

Fouling factors: Usually in decimal form. EG. Fouling = 0.0015

Clean factors: Used in power market and represented as a percentage. EG Fouling = 85% clean factor.

% Excess Surface Area: Used to specify fouling in plate units. EG Fouling = 10% excess surface area.

The amount of fouling to be specified is dependent upon the type of heat exchanger being used.

Dealing with Fouling

Calculating the percent excess surface area:

$$\%\ Excess\ Area = \left(\frac{U_C}{U_D} - 1\right)\ X\ 100$$

For the Engineering Data Sheet, we can calculate % excess surface area:

$$\%\ Excess = \left(\frac{717.9}{638.7} - 1\right) x\ 100$$

$$\%\ Excess = 12.4\%$$

Plate Heat Exchanger Data Sheet		Ref.:	CTK10457/9 (E) Page 1	
Duty:	Closed Cooling Water Heat Exchanger			
Company:	KeySpan Energy			
Project:	Glenwood Power Station, Unit No. 5		Item No:	
PHE Type:	J092		Engineer:	CTK
Quotation No	P3CK03533, R2		Date:	2004.Feb.06
Process Data			**Hot**	**Cold**
Fluid			Water	S.w ater
Mass Flow Rate		lb/h	818000	1023019
Volume Flow Rate		gal(U.S.)/min	1645.6	2000.0
Inlet Temperature		°F	101.0	85.0
Outlet Temperature, Duty		°F	90.0	94.2
Pressure Drop, calculated		psi	1.7	6.45*
Heat Exchange Rate, Duty		BTU/h	8977151	
Design (Duty) HTC		BTU/h°Fft²	638.7	
Clean HTC		BTU/h°Fft²	717.9	
% Difference in HTC			12.4%	
Fluid Volume in PHE		gal(U.S.)	97.0	97.0
Fluid Properties			**Hot**	**Cold**

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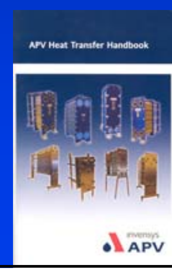
Dealing with Fouling

Most types of fouling are very sensitive to turbulence, the higher the turbulence the lower the fouling growth rate.

Due to the complex flow geometry in a plate channel, the turbulence in a PHE is higher than in a shell and tube. The so-called "self-cleaning effect" is therefore much better in a plate exchanger.

Most customer try to apply the fouling factors of shell and tubes to plate and frame exchangers. That's wrong and leads to more surface area, which slows the plate velocity and can actually promote fouling.

The Heat Transfer Handbook and Corrosion Handbook are great reference guides for specifying fouling factors in plate heat exchangers.



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Specifying Fouling

• Do not apply the same fouling factors as shell and tubes.

• Standard industry practice is to have 10% excess surface area in a plate heat exchanger. It seldom makes sense to incorporate more than approx. 25% excess area in a PHE.

• Too much excess area means less turbulence, which leads to poor self-cleaning effect.

• The higher the heat transfer coefficient, the more efficient the design. However, that also means lower fouling factors for the same 10% excess surface area.

Example: Oil to water duty vs. water to water duty, each having 10% excess surface area

Oil to Water: U_C= 550, U_D= 500 Fouling factor = 0.000180

Water to Water: U_C= 1,100, U_D= 1,000 Fouling factor = 0.00009

Plate Heat Exchangers: installation

installation

4.0 INSTALLATION

4.2 Foundations

The foundation pad for the heat exchanger should be level and sized properly for the outline of the frame. It must also be of adequate strength to support the full operating weight of the unit. The overall dimensions and operating weight are listed on the general arrangement drawing.

4.3 Space Requirements

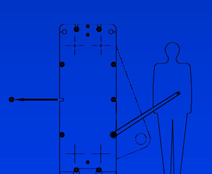

Figure 15

4.4 Connection Figure 16 ping

Pipe lines to the follower and connector grid(s) must be located to allow the unit to be easily opened for inspection and maintenance. These lines must also be flexible to allow for small variations in the tightening dimensions and possible thermal expansion.

4.7 Hydraulic Shock

The plate heat exchanger will be damaged by any hydraulic shock that occurs during start up or operating changes. To avoid damage, throttling valves and soft pump starts are recommended.

4.8 Heat Shields

A heat shield may be provided for new or existing heat exchangers. They are recommended whenever corrosive liquids or high temperatures are present. See Section 9.0 Accessories for more information.

4.5 Pressure Pulsation and Vibration

Piston pumps, gear pumps, valves etc. must not be able to transfer pressure pulsations or vibrations to the plate heat exchanger as this may cause fatigue fracture in the plates. The use of pressure dampers in the pipeline is recommended to minimize this effect.