Understanding the Basics

**Temperature Approach or CTD:**

- Hot fluid inlet: 120°F
- Cold fluid outlet: 110°F
- Hot fluid outlet: 95°F
- Cold fluid inlet: 85°F

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 2°F 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 400°F 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 400°F

**Operating Pressures:**
- Equal to or Below 450 PSIG

**Solids & Particles:**
- **Round:**
  - <= 1/16” dia. = standard PHE
  - <= 1/8” dia. = wide gap PHE
  - > 1/8” dia. — No good

- **Long Stringy:** — 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

Plates are fitted alternately right and left handed to provide alternate flow of liquids.

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

The interspace is vented to atmosphere for leak detection.

Always look at the gasketed side of the heat transfer plate.
Plate Heat Exchanger choices available:

- Single gasketed plate
- Duo-Safety (double wall)
- Welded plate pairs
- Brazed

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
Chevron plates can have different angles.

- **Soft Plate (50° angle)**
  - Thermally short

- **Hard Plate (0° angle)**
  - Thermally long

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.

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
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

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

Sealing detail of the laser welded plate pair

Welded Plate Pairs

- Laser weld
- Laser welded channel
- Gasketed channel

Welded Plate Pairs

- Welded Pair
- Service gasket
- Port ring
- Welded port
**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

**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
A ParaBrazed Heat Exchanger is soldered and therefore cannot 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 cannot be pressed into a heat transfer plate.
To ensure a good fit in the frame, the heat transfer plates hang from a top carrying bar and are guided by a lower guide bar.

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.
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

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

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.

---

Calculating the percent excess surface area:

\[
\% \text{ Excess Area} = \left( \frac{U_C}{U_D} - 1 \right) \times 100
\]

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

\[
% \text{ Excess} = \left( \frac{717.9}{638.7} - 1 \right) \times 100 = 12.4\%
\]
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.


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

<table>
<thead>
<tr>
<th></th>
<th>Oil to Water</th>
<th>Water to Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uc</td>
<td>550</td>
<td>1,100</td>
</tr>
<tr>
<td>Ud</td>
<td>500</td>
<td>1,000</td>
</tr>
<tr>
<td>Fouling factor</td>
<td>0.000180</td>
<td>0.00009</td>
</tr>
</tbody>
</table>
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

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.

4.4 Connections and Piping

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 wherever 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.